Draft Final Report

Strategy Paper For Reducing Urban Air Pollution

Submitted to
Ministry of Urban Affairs & Employment
Government of India

Prepared by the
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodi Road, New Delhi - 110 001, INDIA

October, 1995

Table of Contents

I. Urban air quality profile and the sectoral impacts 1

Urbanisation trend 1

Constituents of air pollution 2

Sources of urban air pollution 2

Ambient air quality status in various urban centres 8

II. Strategies to reduce air pollution 9

Proposed organisational structure 9

Strategies in transport sector 10

Strategies in industrial sector 25

Strategies in domestic sector 35

III. Conclusion 42

IV. A case of Delhi 42

Demography 43

Emissions from transport sector 46

Emissions from industrial sector 47

Emissions from domestic sector 48

Strategies/measures for reducing air pollution in Delhi 50

References

List Of Abbreviations

1.	ARAI	Automotive Research Association of India
2.	BHEL	Bharat Electricals Limited
3.	BHEL	Bharat Heavy Electricals Limited
4.	BOV	Battery Operated Vehicle
5.	C.B.D.	Central Business Dristict
6.	CFLs	Compact Fluroscent lights
7.	CNG	Compressed Natural Gas
8.	CO	Carbon Monoxide
9.	CPCB	Central Pollution Control Board
10.	DDA	Delhi Development Authority
11.	DSIDC	Delhi State Industrial Development Corporation
12.	DSM	Demand side management
13.	DTC	Delhi Transport Corporation
14	EIA	Environment Management Plan
15.	ESPs	Electrostatic Precipitators
16.	FTLs	Flurocent tube light
17.	GAIL	Gas Authority of India Limited
18.	GDP	Gross Domestic Product
19.	GHGs	Green house gases
20.	GLSs	General Lighting Systems
21.	gm/litre	gram per litre
22.	GOI	Government of India
23	HBJ	Hazira-Bijapur-Jagdishpur
24	HCs	Hydrocarbons
25.	IGCC	Integrated Gasification Combined Cycle
26.	IIP	Indian Institute of Petroleum

27.	IIT	Indian Institute of Technology
28.	IRC	Indian roads Congress
29.	IREDA	Indian Renewable Energy Development Agency
30.	JJ	Jhuggi Jhopri
31.	kCal	Kilo Calories
32.	kmhrs	Kilometer per hours
33.	LPG	Liquified Petroleum Gas
34.	MINAS	Minimum National Standards
35.	ml	millilitre
36.	MNCs	Multinational Corporations
37	MNES	Ministry of Non conventional Energy Sources
38.	MOEF	Ministry of Environment & Forest
39.	MOP&NG	Ministry of Petroleum & Natural Gas
40.	MRTS	Mass Rapid Transport System
41.	MW	Mega Watt
42.	NAAQM	National Ambient Air Quality Monitoring
43.	NCAER	National Council for Applied Economic Research
44	NCL	National Chemical Laboratory
45	NEERI	National Environmental Engineering Research Institute
46.	NGOs	Non Government Organisations
47.	NO	Nitrogen Oxide
48.	NO_2	Nitrogen dioxide
49.	NOC	No Objection Certificate
50.	NO_x	Oxides of Nitrogen
51.	NPIC	National programme on improved chulha
52.	PAHs	Polycyclic aromatic hydrocarbons
53.	pb	Lead
54.	PDS	Public distribution system

55.	R&D	Research & Development
56.	SDF	Sugar Development Fund
57.	SEBs	State Electricity Boards
58.	SO_2	Sulphur dioxide
59.	SPCB	State Pollution Control Board
60.	SPM	Suspended Particulate Matters
61.	SSIs	Small Scale Industries
62.	TEDDY	TERI Energy Data Directory & Yearbook
63.	TERI.	Tata Energy Research Institute
64.	TIFAC	Technology Information Forecasting Assesment Council
65.	VOCs	Volatile Organic Compounds

I. Urban air quality profile and the sectoral impacts

In Indian cities, the harmful facets of pollution manifest themselves in our everyday life, the degradation of the air, water and the toxic effects of poorly disposed solid wastes are very common features in many urban centres of the country.

The air quality has deteriorated significantly in urban areas The level of air pollutants in the larger cities has already exceeded the emission standards prescribed by the CPCB (table 2) Abatement of pollution which has reached alarming levels in many urban areas is therefore the need of the hour.

Pollution has long term global effects as well - the rise in the emission of greenhouse gases (GHG) and the consequent climatic change, acid rain, loss of biodiversity etc. Pollution could become a serious health hazard, it can cause respiratory, neurological, heart and circulatory problems. Recent research suggests that air pollutants can be carcinogenic.

How then should we tackle pollution? Taxes and subsidies, information and public awareness programmes, legislation and strict enforcement/penalties, R&D and adoption of new and existing energy and pollution efficient technologies are some of the possible solutions The success of any environmental protection effort depends on its technical feasibility, economic viability and administrative enforceability

Coordination of the institutional mechanisms at the national, state and local body level is essential for effective control over the present level and for the future abatement of pollution Cooperation between the private sector and the government could also be extended to enable better management of our environment.

Urbanisation trend

The pace of urbanization witnessed in India, especially in the last four decades has been truly phenomenal. In 1951, the urban population was 62 million (17.3 per cent of the total). By 1991, this number had swelled to nearly 217 million with one in every four persons living in urban areas. India's population by the year 2001 is expected to touch the 1 billion mark and nearly one third of this population (about 326 million) will be residing in urban areas. An analysis of the pattern of the rise in urban population shows that natural increase accounted for about two fifths of the urban growth, net immigration another two fifths and reclassification (new towns and area changes) about one fifth to the urban population surge between 1981 and 1991.

Urban centres are classified on the basis of population density, land use, workforce engaged in non-agrarian activities etc. The Indian population census categorises urban population into six classes of cities/towns as given in the table 1. Urban agglomerations/cities with a population size over 1 million have been classified as metropolitan cities The 1991 census classified 23 cities as metros

Table 1: Classification of cities

Class	I	II	III	IV	V	VI
Population	100,000 and above	50,000-99,999	20,000-49,999	10,000-19,999	5,000-9,999	less than 5,000

Source Nanda 1991

There has been a tendency for urban populations to concentrate in larger cities Urban growth has mainly occurred in the 'over one lakh' cities (i e the Class I cities) The share of Class II and III towns has remained more or less steady, while the Class IV and smaller towns have shown a steady decline in the last four decades.

The urban sectors' contribution to our country's GDP in 1950-51 was about at 29%, this had increased to 47% by 1980-81 and is likely to rise further to almost 60% by the turn of the century. However, the positive aspects of urbanization are often overshadowed by the deterioration in the physical environment and quality of life. This is largely caused by the ever increasing gap between the demand and supply of essential services and infrastructure

Constituents of air pollution

The most common air pollutants in urban environments include sulphur dioxide (SO_2), the nitrogen oxides (NO and NO_2, collectively termed NO_x), carbon monoxide (CO), suspended particulate matter (SPM) and lead (Pb) Combustion is the principal man-made source of the traditional air pollutants, combustion of fossil fuels leads to the production of SO_2, NO_x and particulates. Petrol-fuelled motor vehicles are the principal sources of NO_x, CO and Pb, whereas diesel-fuelled engines emit significant quantities of particulates and SO_2 in addition to NO_x. Domestic solid fuel use, mainly coal and wood represent a significant source of SPM, CO and other indoor air pollutants in most cities

Although detailed emissions inventories are not widely available for individual cities, on the basis of observed trends in national emissions and the recent increase in vehicle registrations, *it may be concluded that motor vehicles now constitute the main source of air pollutants in the majority of cities*

Sources of urban air pollution

In most urban areas, the three principal sources of air pollution have been the transport, industry and domestic sectors.

Transport sector

Transport plays a significant role in the overall development of the economy. The rapid urbanisation along with the rise in industrial and commercial activities, has increased the demand for transport. As a result, the road length has increased fourfold between 1950-51 and 1990-91 whereas the number of vehicles has grown 77 times, from about 0.3 million to more than 21 million during this period. However, in spite of the impressive growth the *transport network is still far from adequate,* when we consider the country's size (3 3 million sq.kms) and vast population (884 million).

The total number of registered vehicles increased from about 0.23 million in 1971 to 2 5 million vehicles in 1991 (nearly a ten fold increase). About 82% of these are personal transport vehicles with the share of two-wheelers and cars as about 68% and 14% respectively The yearly average increase of two-wheelers has been very high (16%) as compared to that of cars (6 9%) and buses (5.7%) The number of vehicles per 1000 population has increased from 0 85 in 1951 to 25 31 in 1991 and it is expected to cross 40 by the year 2000. The bulk of the vehicular population is found in the urban centres, with about 35% concentrating in the 23 metropolitan cities Delhi itself accounts for more than 8% of the total registered vehicles.

Although the vehicular population in India is still relatively low compared to several European countries and the U S , *the travel demand and the per capita trip rate in India is one of the highest among the developing countries* It is estimated that in the four mega cities of Calcutta, Bombay, Delhi and Madras, the 1986 travel demand of 3.5 million daily trips is expected to increase to about 6 million trips by the year 2000 Regarding road space, in most cities, it is less than 10-12% of the total urban land space as against 20-25% advocated by city planners. Hence the vehicular pollution has become a serious problem in the urban areas. The factors which contribute to vehicular pollution include an increase in travel demand, increase in the number of vehicles, constrained road space, types of engines used, overaged vehicles, quality of fuel, poor road conditions etc.

Air pollutants emitted from gasoline vehicles include carbon dioxide (CO_2) arising from the combustion of fossil fuel, carbon monoxide (CO) and hydrocarbons (HC) resulting from incomplete combustion, nitrogen oxides (NO_x) generated at high combustion temperatures, and lead (Pb) from fuel in which lead is added to attain desired octane rating. Air pollutants emitted from diesel vehicles are CO_2, CO. HC but at rates lower than gasoline vehicles because of better combustion efficiencies, NO_x at a rate higher than gasoline vehicles because of lower combustion temperatures. Diesel vehicles emit no lead but emit fine particulates and higher levels of SO_2.

The pollution problems posed by vehicular traffic in urban areas have already reached alarming proportions. The impact of vehicular pollutants is comparatively more because these are ground level emissions. These pollution problems are further compounded in large cities where atmospheric conditions are stable and there is no vertical mixing or motion of air, especially due to high rise structures blocking its dispersion However, very little information is available (except for few cities) on emission from various modes of transport and their impact on various locations

Industrial sector

The industrial sector accounts for nearly 60% of the nation's energy consumption Nearly 74% of this is in the form of coal, 15% petroleum products and the rest is met by electricity Natural gas consumption in industry is almost insignificant With industry's energy demands increasing rapidly, there is need to augment supplies to cover the shortfalls.

The Indian industry consisted of 13,600 registered factories and a labour force of 2 4 million thirty years ago It has increased to approximately 100,000 factories with a work force of about 8 million and capital outlay of Rs.4,500 million as per the current estimates

Whether large or small, private or government, the growth of industries has resulted increasing air and water pollution. The tanneries of Jajmau (Kanpur) have become a principal source of river pollution (Ganga) and the discharge of tannery wastes in the municipal drains and sewers, with their high sodium and chrome content, has made waste water treatment more difficult In Vaniyambadi in Tamil Nadu, the river water as well as the ground water have become so contaminated as to be unfit for irrigation, leave alone drinking, due to tannery wastes. The chemical factories around Baroda as well as Bombay and the foundries in and around Agra have caused serious air pollution problems Sugar factories and distilleries concentrated in western Uttar Pradesh have seriously affected the Kaki river, a tributary of the Ganga Toxic and hazardous wastes are often discharged into the municipal drains or dumped in municipal garbage heaps. Paper industry is another heavily polluting industry

Concentration of industries have caused land pollution where industrial wastes are dumped, eventually resulting in leaching and pollution of ground water Indiscriminate dumping of fly ash and waste materials from the ceramic and refractory industries are common

Eighteen categories of industries have been identified as significantly polluting (both air and water) such as cement, thermal power plants, oil refineries, petrochemicals, zinc / copper smelting etc The gaseous emissions from chemical industries, SO_2 and nitrates of oxide from fuel based industries, fumes and odours from chemical industries, dust from cement and stone crushers (SPM) etc have been the main sources of air pollution

An inventory of air polluting industries has been prepared which lists about 1,600 units which are required to comply with emission standards About 25% out of these have done so, while in another 40-45%, partial control measures have been installed. In the remaining units, there is no control so far (30-35%).

In the urban centres, particularly in the large metropolitan cities, the pollutants in the air already far exceed the emission standards prescribed by the Central Pollution Control Board (CPCB). The health impacts of such high levels of pollution, are estimated to be alarming. While many of these large industries with high emission loads are in distant locations, many have been set up within or close to urban centres. The thermal power plants in the metropolitan cities of Delhi, Calcutta, Bombay and Madras are examples. The impacts of the refineries in Mathura and Bombay on the surrounding areas, which emit sulphur dioxide, nitrogen oxide, hydrocarbons etc. are quite severe in nature.

While large industries are amenable to control and monitoring, air pollution from the numerous small industries appears to be a significant problem in many urban centres. They generate large amount of waste resulting in more pollution per unit of output than the large units and have a direct bearing on the environment. Despite their higher aggregate pollution potential, they are far less equipped individually, to resolve the problems. While the large and medium size industrial units, generally, do possess the requisite technical, financial and legal capabilities to deal with their pollution problems, the Small Scale Industries (SSI) however, lack information, technical expertise as well as financial resources. Despite such explicit differences, the policy, approach and statutory stipulations, are more or less identical for both SSIs and larger industrial units.

Moreover, the SSIs are neither aware that they are polluting nor they posses the information on legal repercussions if they do not comply. Most of them do not have any knowledge about the pollution control measures either. Various studies have shown that most of the pollution is being caused for lack of knowledge on the part of SSI entrepreneurs as well as its workers that he is polluting.

Waste from individual SSI units may be small, but it aggregates to a large quantity. (For example, the stone crushers in Delhi throw a sizeable amount of suspended particulate matter daily and the dust concentration around them varies from 3,000 to 8,000 micro grams per cubic meter of air which is 15 to 40 times prescribed. There are 2150 acid, chemicals and paints factories scattered in almost all of Calcutta's municipal wards. Concentration of carbon monoxide and SO_2 are reported to be very high).

Domestic sector

The lure of jobs and facilities available in the cities have resulted in a large inflow of people to the urban centres. There has been no concomitant increase in the infrastructural facilities as most towns and cities are ill equipped to deal with the rapid pace of urbanization.

The shortages in housing has led to the development of slums and other "kucha" housing structures particularly in the larger cities. These houses usually have inadequate ventilation. The various types of energy sources used in urban households include liquified petroleum gas (LPG), kerosene, soft coke, electricity, firewood & other biomass fuels LPG and electricity are generally used by the higher income groups, while the lower income brackets choose kerosene, coal and biomass fuels. The main concern in the domestic sector is the use of inefficient and highly polluting fuels in the poorer households (urban slums), leading to a deterioration in the indoor air quality and health

The burning of biomass fuels in inefficient cookstoves and in the absence of chimneys and windows leads to high levels of indoor air pollution causing a variety of eye and lung diseases; especially among the women and children. The CO, CO_2, SPM emissions from fuel use are fairly significant and are inadequately dispersed. This brings about high exposure and risk to the slum dwellers. Hence alternatives to the use of such fuels need to be examined and the use of smokeless chullah, biogas plants etc. could help mitigate some of the problems faced by the urban poor.

Ambient air quality status in various urban centres

The CPCB has in pursuance of the Air Act (1981) published air quality standards Geographical areas have been categorized into three classes for the purpose, viz , Industrial & mixed areas, Residential & rural (commercial) and Sensitive areas The CPCB has been monitoring air quality since 1984. By March 1992, 290 stations spread over 89 cities/towns were monitoring air quality under the National Ambient Air Quality Monitoring (NAAQM) network. The air quality of some of the cities are presented table 2 below·

Table 2: Pollution level in selected cities

	City		Location Code	SO$_2$			NO$_2$			SPM		
				Yearly Average		CPCB standard	Yearly Average		CPCB standard	Yearly Average		CPCB standard
				1990	1991	$\mu g/m^3$	1990	1991	$\mu g/m^3$	1990	1991	$\mu g/m^3$
1	Agra	Industrial & Mixed Areas	3	22.3	17.0	80	12.0	11.3	80	478	467	360
		Residential/Commercial	2	19.8	16.4	60	11.1	19.0	60	502	456	140
		Sensitive Area	1	22.2	21.1	15	12.7	11.8	15	437	519	70
2.	Ahmedabad	Residential/Commercial	102	33.4	68.1	60	36.6	52.9	60	357	390	140
3	Baroda	Residential/Commercial	47	8.1	10.0	60	13.4	16.1	60	357	393	140
4.	Bhopal	Residential/Commercial	122	24.7	16.5	60	31.7	11.0	60	594	361	140
5	Bhilai	Residential/Commercial	65	37.7	24.2	60	24.0	38.1	60	329	269	140
6.	Bombay	Residential/Commercial	168	28.2	21.6	60	24.5	29.4	60	228	298	140
7	Calcutta	Residential/Commercial	163	38.5	67.6	60	42.0	53.8	60	274	364	140
8	Chandigarh	Residential/Commercial	108	4.3	4.3	60	13.3	6.1	60	270	253	140
9	Dehradun	Industrial & Mixed Areas	90	27.6	26.4	80	24.5	23.8	80	837	900	360
		Residential/Commercial	89	26.0	23.7	60	23.2	21.0	60	506	553	140
10.	Delhi	Industrial & Mixed Areas	145	32.5	31.3	80	42.6	45.6	80	527	568	360
		Residential/Commercial	146	30.6	51.2	60	51.5	61.7	60	568	643	140
11.	Dhanbad	Residential/Commercial	104	31.8	45.0	60	44.4	53.3	60	291	360	140
12	Faridabad*	Residential/Commercial	42	30.7		60	10.0		60	315		140
13.	Howrah	Industrial & Mixed Areas I	8	69.9	63.5	80	75.7	81.7	80	560	383	360
		Industrial & Mixed Areas II	10	81.8	71.5	80	90.8	83.4	80	315	321	360

				Pollutant								
				SO$_2$			NO$_2$			SPM		
	City		Location Code	Yearly Average		CPCB standard	Yearly Average		CPCB standard	Yearly Average		CPCB standard
				1990	1991	μg/m^3	1990	1991	μg/m^3	1990	1991	μg/m^3
14	Hyderabad	Residential/Commercial	152	7 4	10 3	60	21 1	32 3	60	154	178	140
15.	Indore	Residential/Commercial	128	12 6	22 4	60	17 5	30 4	60	358	442	140
16	Jaipur	Residential/Commercial	156	5 5	7 5	60	18 5	19 2	60	502	357	140
17	Kanpur	Residential/Commercial	98	9 8	13 5	60	13 3	14 4	60	566	588	140
18.	Kota	Residential/Commercial	20	15 7	16 0	60	101 2	92 8	60	228	209	140
		Sensitive Area	18	13 7	13 0	15	68 1	73 3	15	151	105	70
19.	Ludhiana	Industrial & Mixed Areas	76	22 9	16 4	80	43 6	68 9	80	516	551	360
		Residential/Commercial	62	13 0	0 0	60	39 9	40 9	60	258	237	140
20	Madras	Industrial & Mixed Areas	71	54 1	33 2	80	22 8	23 1	80	103	95	360
21.	Nagda	Residential/Commercial	84	7 2	10 8	60	16 0	24 3	60	282	226	140
22	Nagpur	Residential/Commercial	166	7 5	9 5	60	11 4	11 3	60	240	217	140
23.	Pune	Residential/Commercial	54	13 6	16 8	60	42 2	36 9	60	273	197	140
24.	Shimla	Residential/Commercial	35	3 4	3 9	60	17 3	12 4	60	252	255	140
		Sensitive Area	34	3 2	3 5	15	18 1	12 6	15	160	101	20
25	Surat	Residential/Commercial	23	21 1	20 8	60	37 7	24 6	60	416	407	140

Source. CPCB, National Ambient Air Quality Statistics of India, 1990/1991

Table 2 above broadly indicates the gravity of the situation. The CPCB ambient air quality standards (1982) for SPM are exceeded in most of the cities/towns across the nation. Dehradun, has recorded the highest concentration of TSP of all the monitoring stations. For NO_2 the annual mean value exceeded the standard in Kota. SO_2 levels were high at Ahmedabad, Howrah, Delhi and Calcutta. The annual mean values for concentrations of NO_2 at Ahmedabad, Calcutta, Delhi, Dhanbad, Howrah and Ludhiana though within the stipulated standards, were on the higher side.

Grounded in this vision the Tata Energy Research Institute, New Delhi has discussed in the following section (a) an Organisational Structure to facilitate implementing various measures in urban areas and (b) various issues and strategic options with recommended measures to reduce the sectoral emissions and control the urban air pollution.

II. Strategies to reduce air pollution

Proposed organisational structure

The existing institutional mechanisms for controlling urban environment is dealt in depth in the 'Strategy Paper on Institutional Strengthening of Urban Environmental Management', by the National Institute of Urban Affairs. It is evident from the rapidly deteriorating environment that these mechanisms are not sufficient to control or regulate the situation.

Presently, the Ministry of Environment and Forest (MoEF) and Central & State Pollution Control Boards (CPCB & SPCBs) are responsible for the environment. While MoEF decides on policy issues, the SPCBs monitor and enforce compliance with pollution standards However as urban environmental problems are largely specific and local in nature, their solutions are local too. Thus, at present, local issues are dealt with at the central/state level, and the strategies/measures adopted are often inadequate. It is imperative that the city specific environmental problems are tackled at the local/city level. *A broad guideline to incorporate the above could be a committee (MC) formed at the city level with the Municipal Commissioner as the Chairman comprising representatives from SPCBs, Urban Development Agency, Department of Transport, Industry, Railways, Confederation of Indian Industries (CII) and other relevant organisations. This would of course require a legal regulatory framework without which the committee would not succeed in implementing its recommendations.* The MC will meet periodically to-

- discuss the environmental problems and their causes
- identify critical zones
- analyse various strategic options
- select the viable measures
- identify suitable organisations for implementing the measures and

- ensure proper enforcement as per the guidelines of the regulatory framework

Particularly in large cities, while addressing the first four components the MCs may like to take help of suitable organisations/ NGOs/ individuals for their expert opinions The MC will also carry out periodical monitoring of these projects during implementation as well as after completion. The committee must be made responsible for maintaining the city's environment and should be empowered to take decisions/actions on various environmental issues. *This would of course require a legal regulatory framework without which the committee would not succeed in implementing its recommendations.* For larger projects the Committee would require to approach the MoEF and Ministry of Urban Development

The above is only a broad guideline to introduce the local component for managing the urban environment in an effective manner This forms the basis on which a detailed organisational structure could be developed.

Various issues and measures in the different sectors of transport, industry and domestic are discussed at length in the subsequent sections Depending on the city size and its characteristics, the MC in each city could consider the feasible measures for adoption and implementation.

Transport sector

The major transport sector issues leading to increased urban pollution levels are

- Increased use of personal vehicles;
- Congested transport network and poor level of service;
- Technology development: pollutant load reduction at source;
- Absence of HC emission standards & inadequate pollution checking

The various issues concerning the vehicular pollution and the possible strategies and measures to overcome them are detailed in this section.

Issue 1/ Increased use of personal vehicles

Given the rapidly rising transport demand and the high environmental costs of private vehicles, the obvious choice should be to encourage public transport. *Urban transportation in India is primarily personalised vehicle dependent,* about 91.6% of the total registered vehicles in the metropolitan cities are personal vehicles with the share of two-wheelers being 68% and that of cars and buses at 20% and 1.4%. The travel demand is also increasing considerably and the mass / public transport system in all cities is incapable of catering to this demand.

The mass transportation system in India, consists of bus (private/ public or both), rail (intracity, suburban or metro) or tram (used in Calcutta). The bus system exists in all large urban centres and is supplemented by the rail/tram system in the metropolitan cities. The role of intermediate public transport system (IPT), motorised (three wheelers) and non-motorised (cycle rickshaws), is also significant. In the medium and small cities this may often be the only form of public transport for the intra-urban area trips.

In the metropolis, the bus is used extensively, so is the rail in Bombay and the tram and EMUs in Calcutta, especially in the peak hours when it is inevitably overcrowded. (The metro of Calcutta and the ring railway of Delhi however lies underutilised). *In the medium and small cities the bus system is observed to be underutilised.* However, irrespective of the urban centre size, in all large, medium and small towns the number of private vehicles are increasing at a fast rate. Hence it is seen that inspite of having a mass transport system, there is a prevalent tendency towards the use of personalised vehicles or the IPT (even at a much higher operating cost). The various reasons which can be attributed towards this situation are:

- public transport system inaccessible to commuters with the absence of feeder service between residential area and bus route
- relatively more time consuming and uncomfortable public transport;
- rise in incomes and easy availability of credit resulting in increased ownerships of private modes.

The increased ownership of personal vehicles has led to an enormous increase in the total number of vehicles while the area under road network remained more or less constant. This has led to traffic congestion, and corresponding inefficient fuel utilisation, finally resulting in severe aggravation of the air pollution problems. Unfortunately, *the number of buses, the main form of public transport has been growing at a much slower rate as compared to the actual passenger demand.* Adequate steps need to be taken in order to provide additional capacity and ensure the optimal use of this system.

However, when buses cannot remain to be the principal mass transport mode as the requirements exceed 20,000/25,000 passengers per hour, other rail based transit systems have to be considered on the corridor. Rail based MRTS exists only in a few cities. In the case of Calcutta, excessive delay took place in construction. In Madras, an elevated rapid transit line is under consideration. In the case of Bombay, a surface railway line to the twin city of New Bombay has been completed *jointly funded by the State Government along with the Railways.* Schemes for rapid transit have been studied several times but any specific project is still to be determined for Delhi. Hence the availability of a viable MRTS (bus/rail/both) is vitally important in order to control and improve the situation.

Railways who have been operating suburban systems and who have the requisite technical expertise to build rail based systems for cities are unwilling to get into the urban transport sector because of the high capital costs and low fare structure making it economically not viable Possibilities of raising resources through other innovative means such as integration of real estate developments special charges etc. needs to be worked out.

Strategy: Facilitate modal shift from personalised to public transport

The following measures are recommended for reducing the dependence on personal vehicles.

Measure 1: Parking facility at bus terminus/depot

Provide parking facility for personal vehicles at bus terminal/MRTS station enabling usage of public transport for the onward trip upto destination. For example, in the case of Delhi, DTC intends to exploit land holdings (allotted for terminal premises) by constructing commercial centers; (fleet is reducing). The achievement of the desired enhancement in incomes for DTC can be met by priced parking provision (car/two wheelers), even though the actual returns would be in the long term. The actions required are·

Short term: The transport department of the city would submit the proposal for designing the parking spaces to the proposed municipal committee (MC) who will sanction and execute the same. The parking fees generated can be shared by the municipality and the respective authority in charge of the terminal area and utilised in an effective manner.

Long term. Develop multi storeyed parking and interface with any mass rapid transit system (private mode/IPT-to-public bus/ MRTS integration).

Measure 2: Improving the role of non-motorised intermediate public transport

Short term: The slow moving cycle rickshaws operating on the major roads tend to increase traffic congestion. It is proposed that city/town be divided to different zones surrounded by the arterial roads and IPT be introduced such as to ply within the zones, interconnecting public transport access points from the residential to social/ educational/ religious/ cultural/ health/ work etc. destinations. Zone crossing by IPT can be prevented by colour coding of the IPT vehicles combined with imposition of significant fines/ penalties. The municipal committee be made responsible for its implementation and effective operation.

Measure 3: Mandatory use of office vehicles by employees for work trips

The various industrial houses/ government, semi-government organisations/ public sector undertakings in the large/medium/small and the industrial towns need to promote reduced use of personalised vehicles by providing buses for their employees. This proposal is especially recommended for organisations whose employees are provided housing in designated areas by the employer in one or different pockets of the city.

Short term: Mandatory car pooling in the initial stage. Instead of providing official vehicles to individuals, these vehicles could be used by a group of people.

Medium term: Provision of buses at a later stage after the system is stabilised. (Disposal/ auction of excess personal use vehicles to offset part of cost and rest be generated from organisational profits wherever possible).

An order by the Ministry of Urban Development/Ministry of Environment and Forest is required to be circulated to all the relevant organisations and their implementation is to be confirmed.

Measure 4: *Introduction of mass rapid transport system*

Studies have revealed that in large cities where traffic on major roads have crossed 20,000-25,000 passengers per hour, there is an urgent need to introduce MRTS. The MRTS alignment should pass locations of traffic-generating activities such as offices, business and commercial centres and higher educational institutions

Since implementation of MRTS is a very large project requiring a huge investment, it may be handled by any central authority. The MC, however, would have to get prepared a detailed techno-economic feasibility report and then submit it to the body as well as Ministry of Urban Development and MoEF. The funding could be on privatisation basis. The other possible sources of funding are:

- International funding (World Bank, Asian Development Bank, OECF and others) on soft loan basis.
- Loan from national organisations like Life Insurance Corporation of India (LIC), General Insurance Company (GIC), HUDCO etc.
- Through Public Private Participation (various mechanisms can be adopted, for example; BOT-build, operate and transfer; BOOT-build, operate, own and transfer; or BOLT-build, operate, lease and transfer)

Short term: In cities where requirement of MRTS is anticipated in near future, ensure proper road development by demarcating the potential MRTS routes.

Medium term: Initiate setting up of the Corpus Fund.

Long term: Phasewise implementation of the project.

Issue 2/ Congested transport network and poor level of service

The prevalent road network in Indian cities is inadequate and of poor quality. The total area under road network varies from 6% (in Calcutta) to 17% (in Bangalore). The road right of ways are inadequate in width as it is, which are further, full of encroachments and additionally in a very poor state of maintenance. Most do not have medians to segregate directional traffic The level of service is therefore very poor. Signalling system does not exist at junctions in most cities leading to confusion resulting in congestion and occasional accidents. The carrying capacity of the roads, especially in metropolis are exhausted. The Indian Roads Congress (IRC) specifies carrying capacity of roads, but all roads have exhausted their capacities and they are carrying much more traffic than specified

In India, the share of slow moving vehicles and pedestrian traffic is also significant A large number of the urban population is dependent on non-motorised modes like cycles and cycle-rickshaws. For instance, in cities like Jaipur, Kanpur and Lucknow, over 25 per cent of total trips. Cycles are also extensively used by the low income commuters of large cities For instance, in Delhi, 40 percent of work trips in the low income commuter group are met by cycles. Whereas, a higher percentage shift towards the non-motorised transport (cycles/cycle-rickshaws) ensures reduction in the pollutant load, the non-motorised transport mode reduces corridor speeds when mixed with vehicular traffic resulting in a net increase of overall pollution. As cities expand in size, a shift towards the use of motorised modes of travel is also inevitable due to increase in the trip lengths. Traffic management measures play a very important role to reduce congestion on roads facilitating a smooth flow of traffic (with less idling) and less pollution. In order to achieve this, the following strategy and important measures are to be adopted.

Strategy: Ensure smooth flow of traffic

Measure 1: Removal of encroachments and improved maintenance of the existing roads

Short term. Process of time bound encroachment removal drives by concerned departments of municipalities, mandatorily repeated. All encroachments on roads, footpaths/ pedestrian walkways be removed with immediate effect. Failure be resultant in withholding of part of financial grant/aid by concerned state government. High penalties on material dumps on corridors. Present country wide general practice is observed to be, that, any kind of demolitions are in response to complaints from local residents. This system be modified Municipal Zone/ Division/ Sub-division incharge be made duty-bound to carry out daily/ weekly/ monthly checks and report with dated photographs. To counter connivance/ malpractice, concerned official should be made reprimandable to the effect of immediate suspension in case of complaint received from any local resident. Method be available (for any city dweller) to lodge complaints within 24 hours.

Measure 2: Capacity Augmentation

Short term: The immediate short term action could be through traffic management schemes such as one way movement patterns and entry restrictions from identified points on busy roads, no onstreet parking etc. This has been found to be applicable in centres of cities/ towns of all sizes and other congested parts of large cities/ metropolis. There is negligible cost involvement. *(However, whereas the large metropolis have the financial resources to conduct the necessary studies and implement the suggested, the case of all small and medium towns have been found lacking due to the want of resources both technical as well as fiscal Whereas, the technical support can be gathered through competitive tender bids in national newspapers, the generation of adequate financial resources can now be expected in the long run. As an immediate step, funds may be loaned through the concerned State Governments from national/ international funding agencies)*

Medium term: On occasions it is necessary to undertake road widening schemes in order to upgrade an existing corridor to the stipulated "arterial or sub-arterial" level involving the demolition of adjoining structures. The widening schemes become resisted issues in spite of the public purpose behind the whole scheme. Such interferences need to be entirely stopped even if requiring the intervention of the Ministry of Urban Development or the parliament.

Measure 3: Grade separation of busy intersections

Provide flyovers or bypasses to reduce delay, engine idling and resultant pollution. Implementation is either in the longer time perspective consequent upon the corridor capacity augmentation schemes detailed immediately above, or case specific and typically, shortly achievable whenever the existing demand is of an immediate nature. In the present scenario, the municipal bodies are responsible for the schemes' implementations.

All the 3 above mentioned measures would be the responsibility of the proposed municipal committee. The actions are to be taken with a reasonable share of financial aid from the State government, to begin with.

Measure 4: Landuse planning

Long term. Since most of the Indian cities are experiencing shortage of road capacity, due emphasis is required in providing adequate share of land under road and other transport related use while developing an urban extension project This would involve preparation of urban maps indicating the existing and proposed land use, the environmentally critical zones, ground water potential, industrial locations, slum pockets etc. The MC would have to initiate the whole process.

The following traffic management and policy measures would also reduce the traffic congestion.

Measure 5: Staggering working hours

Short term: Staggering of working hours effectuates spreading the load on both, the roads as well as the mass transport system. This is an optimal and implementable solution and should be adopted in cities where an established prominent peak hour volume is noticeable The promotion of staggered working hours by city authorities is a desirable option considering the small expenses involved. (As practiced in Delhi, the schools and offices can function at different hours)

Measure 6: Staggered cargo movement hours

Short term: Cargo movement by trucks be allowed only between 9 p m and 6 a m (this is already being practiced in many cities) Over loading of the trucks and other goods vehicles may be checked effectively. Heavy penalty may be enforced in case of non compliance.

Measure 7: Appropriate siting of bus stops

Short term: Bus stops should not be provided near traffic crossings and roundabouts to prevent congestion The location of bus stops with proper sheds should be fixed by municipalities/ transport authorities for existing areas For proposed developments, the locations should be specified by Development Authority to be mandatorily implemented by the MC

Measure 8: Separate lane for slow moving traffic

Short term: The roads carrying a large share of cycles and cycle rickshaws, to have at least one dedicated lane/track of requisite width (if required, the particular lane would be segregated by temporary barriers during peak hours). The traffic police in large cities and municipalities in medium and smaller cities would be responsible for strict maintenance of system and compliance by traffic.

The municipal committee in each city would be responsible for implementing the 4 above mentioned measures (measures 6,7,8 and 9) for the respective cities.

Issue 3/ Technology development: pollution reduction at source

Serious efforts are needed to upgrade the various technologies with a view to reduce pollution at source. These could range from engine or vehicle design modifications, improving quality of fuel, alternate fuel or environment friendly power pack and stricter implementation of emission standards. Issues of immediate concern are discussed below.

Strategy 1: Vehicle/ engine design modification

Measure 1: Four-stroke technology for two-wheelers

Short term: This is essential for reducing hydrocarbon emissions. As of 1991, 68% of all registered vehicles have been observed to be 2 wheelers The prescribed pollution standards for 2 wheelers is higher than those for four wheelers in general. A large percentage of the Indian 2 and 3 wheelers are run by two-stroke engines. Production of 2-wheelers powered by 4-stroke engines have been initiated by Bajaj and Hero Honda. The problems regarding the existing design of 2-stroke engines is that 25 to 40% of the fuel supplied is discharged without being combusted which results *in very high emissions of unburned hydrocarbons* Thus, in case of 2/3-wheelers, replacing a 2-stroke engine with a 4-stroke one would improve fuel efficiency by 25% in the least and reduce pollutant discharge to the atmosphere by a significant amount. However, the proposed emission standards of 2/3-wheelers applicable from April, 1996, would not be met by the existing 2-stroke engines; thus enabling 4-stroke engines adopted mandatorily.

Measure 2: Modifications for Indian trucks and buses

Medium term. In most cities, the trucks are usually overloaded resulting in high levels of exhaust smoke and particulate emissions. The buses in India have truck chassis designed for a payload of 10t while the actual loading does not exceed 7t. Engine design modifications with regard to practical payload would lead to reduction in the laden weight of a bus This would naturally lead to lower fuel consumption and lower pollutant emissions.

Short term: Commercially available technologies for saving fuel on trucks and buses include use of turbochargers, improved fuel injectors and injector pumps. Combined with the use of improved lubricants, radial tyres and cabmounted front air deflectors and reduced aerodynamic drag by innovative vehicle body design can achieve greater fuel efficiency, leading to significant savings in fuel.

For these two measures involving vehicular design modification a proposal/note needs to be submitted by MoUD and MoEF to the Ministry of Industries who would then bring out a circular for the vehicle manufacturers for adoption. The incentive schemes also need to be specified. Although some developments in upgrading and promoting technology transfer have already started taking place, it needs to be more ingenuous. The recent liberalisation policy in India has facilitated joint ventures with other countries to set up environmental friendly automobile technologies This is a welcoming step and also will create a competitive market.

Strategy 2: Adopt Clean Fuel Technology (Electric vehicles, Compressed Natural Gas operated vehicles)

(1) Battery operated vehicles (bov)

The bovs are noise free, pollution free, represent a more comfortable ride and conserve petroleum products Promotional schemes by way of financial support in the form of grants and loans are available to the operators and manufacturers of bovs from two sources, (i) Subsidy / grant from the Ministry of Non conventional Energy Sources (MNES) and (ii) Soft loan by the Indian Renewable Energy Development Agency Limited (IREDA). The grant is offered to Government/ Semi-Government/ Private Organisations, Registered Societies etc., for the purchase of a passenger bov's of specified make/model

At present there are about 200 battery operated buses operating all over India, consisting of passenger models (using 2 sets of batteries) and industrial models (1 set of battery) The passenger models are the 18 seater buses/vans manufactured by M/S Bharat Heavy Electricals Limited (BHEL), Bhopal and M/S Chatelec, Bombay Recently, M/S Eddy Current Controls (India) Private Limited, Kerala has started producing 2 seater cars The Industrial models (manufactured by Maini Materials Movement Private Limited, Bangalore, BHEL and Chatelec) are primarily fork lifters and used for intra-factory material movement Peerless Developers in collaboration with Frazer Nash of U.K would be introducing four seater battery operated vehicles soon which can replace the existing 3-wheelers.

The initial investment cost is about three to four times the cost of the 3-wheelers and the battery would have to be replaced every 3 years. It has been assessed that the feasibility of their operation lies only with an increased passenger fare structure (compared to 3-wheelers). A concession on electricity tariff for recharging of battery suppresses the actual fare hike required.

***Measure:** Penetration of bov vehicles*

Short term: *(1) Bovs for city centres* In all metropolitan cities, *about 10% of the total fleet of buses would be battery operated if they were to ply on the congested c.b d areas and busy routes during peak hours mandatorily* (The routes be decided by the transport authority and the MC). Suitable storage space for battery replacement facility would have to be decided keeping in mind that with 2 sets of batteries, the bov bus requires recharging after travelling 100-120 kms, which is about 4-5 hrs of running time and whereas it takes 8-10 hours for recharging. Considering that a bus travels about 200 kms approximately per day, the required number of batteries that would have to be stored, works out to be more than twice the number on the running buses. The recharging can take place within the bus terminals. Municipality/ Development Authority has to make available the lands for setting up battery change nodes similar to any refuelling station. In case the bov buses are run under one city transport organisation, the existing fare structure in public bus would have to be increased only marginally in order to offset the higher initial investment for bovs'. Introduction of bovs, a facility in city centre areas, combined with higher parking charges (for personal vehicles) compared to the rest of the city would act as a deterrent to private modes and could significantly reduce pollutant load generated in the city centres.

(2) Employer provided bov buses: In case of employer provided buses as an option mentioned earlier, bov buses should be made compulsory in large cities where pollution problems have already crossed acceptable limits. The cost incurred for investing and operating the bov buses can replace the expenditure incurred due to provision of personalised vehicles.

Medium term: *Introduction of the battery operated I.P T in place of 3 wheelers* (four seater four wheelers by Peerless Developers). Although the operating cost of this bov has been reported to be less compared to the 3-wheelers, the high initial capital cost and recurring cost of battery replacement may act as an obstacle for their successful commercialisation. Concessional loans to cover initial costs and another loan system for the purchase of batteries every 3 years to prospective vehicle operators could facilitate the acceptability of this type of BOV. By "concessional" it is meant to imply an amount of pay back rate which converted into a daily figure, in the least equals the corresponding daily amount for any hypothecated 3 wheeler at present going rates. Since it is doubtful that an average Indian IPT operator would be able to save up (on daily basis) the sum required for the purchase of the battery after the technically stipulated period, it is justified to provide the loan during every battery replacement under normal circumstances

Concessional electricity tariff should be applicable to the operators for battery recharging since the Plant Load Factor (PLF) increases due to charging of batteries by off-peak electricity at night. Publicity and mass awareness regarding this environment friendly vehicle should be done by media, Government and other appropriate agencies/institutions.

(3) Alternate fuel· compressed natural gas

The use of CNG bring down the vehicular pollution levels considerably Conversion kits fitted to the vehicles can render them operable on dual fuel mode, CNG as well as petrol and diesel on a bi fuel mode. A pilot project has been taken up by Gas Authority of India Limited (GAIL) since December 1992 for conversion of passenger vehicles (and a few buses) and their related operationalisation aspects using CNG in Bombay, Delhi and Baroda

The Justice Saikia Committee has suggested a national grid with a pipeline network connecting metropolitan cities. However, acceptability of CNG as alternate fuel also depends on the policy decision of the MOP&NG for allocation of sustained quantity of CNG to the Transport sector, keeping in view the requirements of sectors such as industry (fertilizer), power plants etc, which are gas-based. The MOP&NG have stated of the HBJ pipeline that upto 1996-97 the allocation is exceeding the supply of natural gas Any additional allocation to transport sector would therefore have to be made by reducing allocation elsewhere

The Government is giving exemption on Customs Duty on the CNG converter kit imported into the country. This has brought down the price of a converter kit by about 15% The cost of a Diesel-CNG kit fitted onto buses is about Rs 85,000/- and that of a petrol-CNG kit is about Rs 30,000/- exclusive of customs duty.

Diesel-CNG vehicle technology· State-of-the-Art

The dual-fuel technology is under experiment with some of the DTC run buses, in Delhi *Trial-run reports indicate insignificant reductions in emissions* As per the dual-fuel technology, the engine is run only on diesel low speeds and at speeds above 30km/h, CNG is also let in along with diesel. Buses plying on Delhi roads rarely pick up high speeds Consequently, diesel substitution is not enough to effectuate emission reductions significantly Whereas of all Indian metropolitan cities Delhi registers the highest average traffic speed at 30 kmph.

To mention here, in some countries diesel engines have been converted for dedicated CNG use. This requires complete change in the design of engine and the automobile manufacturers would have to study the cost implications further.

Petrol-CNG vehicle technology: State-of-the-Art
GAIL initiated a pilot project in December 1992 for conversion of petrol vehicles to use CNG. Five CNG dispensing units were set up in Delhi, a few in Bombay and the 2 in Baroda and about 1000 petrol-run vehicles have been converted to the petrol-CNG dual fuel mode of operation. Unlike the bi-fuel option, in the dual-fuel mode the engine is either run on CNG or on petrol.

Although not many vehicle owners in Delhi have converted their vehicles to CNG, it has picked up in Bombay. In Delhi, many of the taxies have converted their engines to run on diesel and hence there is not much scope for conversion to CNG use. The other constraint of using CNG, is that a major part of the vehicle boot space in vehicles is occupied by the cylinder restricting the storage space.

Short term: Since CNG is essentially a new technique, a well-conceived awareness programme coupled with financial assistance needs to be considered. Government sponsored educational seminars, training programmes and distribution of relevant information through pamphlets, brochures etc. would serve concern about safety and performance of natural gas operated vehicles.

Medium term: Incentives and financial assistance to (i) individual owners / operators & (2) for setting up CNG fuelling stations need to be considered for promotion of CNG operated vehicles. For example, in Canada and Denver, USA, each vehicle operator - commercial or individual, was given grant of $ 600 and rebate of $ 200 per retrofit respectively for conversion of their vehicles to CNG mode of operation. Again, in New Zealand, a 25% grant is available on the capital cost of establishing filling stations. The Canadian department of energy provides taxable contribution of 50,000$ for each refuelling stations which typically costs around $ 2-2.5 million each.

Long term: The gas pricing policy is a very critical aspect. Although it may sound pessimistic, the fact remains that our dependence on liquid fuels is so deep rooted that it may take sometime before any alternative fuel can replace them in a big way. Even a potentially viable alternative like CNG may be cast aside if the gas pricing policies fail to provide the necessary incentive for its use. Economic feasibility of any alternate fuel is very sensitive to fuel price and the rate at the filling station is therefore of extreme importance in the initial stage in order to ensure a guaranteed payback within a reasonable time The government, therefore, should consider these aspects while deciding the priorities and pricing structure of the CNG program

Both these strategies of promoting alternate fuels and alternate power pack (battery operated vehicles), should be taken up by the MoUD and MoEF jointly with the Ministry of Industries and other relevant organisations. Ministry of Non-Conventional Energy can continue with their policy of grants and subsidies.

Strategy 3: Promote use of unleaded gasoline

Lead additives are added to petrol to enhance its anti-knock properties It is estimated that only 30% of the lead is deposited in the engine and *the balance 70% is exhausted* out of the tail pipe into the atmosphere as inorganic salt which can be readily absorbed by people While the permissible limit for lead is 2µg/100 ml of blood, an average citizen in a metropolis in India has a lead level between 3 to 82 µg/100 ml of blood The first step of introducing petrol with a maximum lead content of 0 15 grams per litre (which was 0.56 gm/litre) in the four metropolitan cities of Delhi, Bombay, Madras and Calcutta has already been implemented by the Ministry of Petroleum & Natural Gas since December 15, 1994. the programme of supplying petrol with lead content of 0.15 gms/litre to the entire country by December 1996 should be carried out effectively

Catalytic converters are required to be fitted in the cars in order to use unleaded petrol All new cars registered in the four metropolitan cities since April 1995 are being mandatorily factory-fitted with catalytic converters. No additional costs towards the catalytic converters are presently being charged and also the unleaded petrol costs equal to the leaded variety The limited availability of unleaded petrol, even in the metropolitan cities, is causing difficulty in adoption of cars fitted with catalytic converters

Measure: Supply of unleaded petrol and Adoption of catalytic converters

Presently, catalytic converters have to be imported on a national scale. The National Environmental Engineering Research Institute (NEERI) has been involved in R&D for developing an indigenous, lead-resistant, cost-effective catalytic converter for Indian conditions, under a three-phased programme. Under the first phase, which has been completed, the test results indicate that the use of a catalytic converter reduces the carbon monoxide and hydrocarbon concentrations in petrol-driven vehicles to the tune of 50-60% The vehicles however need to be maintained properly and run at stipulated speeds.

The National Chemical Laboratory, Pune is also presently engaged in the development of a catalytic converter for Indian vehicles, under a project sponsored by DST and involving BHEL, IIP, NCL and ARAI (Automotive Research Association of India). The first phase of the laboratory work on non-noble-metal based catalysts for total oxidation of HCs and CO has been completed. The next phase involves testing of the same for long-term activity and stability under Indian road conditions. The success of these trial runs are yet to be established.

Medium term· *An action plan has been prepared for introduction of unleaded petrol in the country in a phased manner* The action plan regarding supply of petrol all over India with zero lead content needs to be implemented. Simultaneously an action plan needs to be prepared and executed regarding production of catalytic converter fitted vehicles throughout the country.

Issue 4/ Absence of HC emission standards and inadequate pollution checking

Strategy 1: Stricter Emission Norms/ standards

The most direct and effective way of dealing with automobile pollution is to formulate and enforce emission control standards. These need to be taken up at the production stage itself. So far as new vehicles are concerned, fuel efficiency and emission standards are determined under the Motor Vehicles Rules, 1989. The Environment Protection Act has also laid down standards for production of vehicles as at present, by 1995 and by 2000 For the petrol driven vehicles, the standards can be achieved only with unleaded petrol. For diesel vehicles, the sulphur content in diesel has to be reduced to 0 25% The vehicle manufactures themselves are responsible for conformity to these standards as part of the production process and the Automobile Research Association of India at Pune which is supported by the Department of Industry as well as the vehicle manufacturers as responsible for monitoring this conformity.

In case of petrol driven vehicles, the two major pollutants are carbon monoxide and hydrocarbons. However, the central motor vehicles rules, 1989 has not prescribed any standard for HC pollution levels. Hence, in absence of standards, the Transport Department is unable to take action against petrol vehicles, having excessive HC levels The autorickshaws are the most polluting class of vehicle with a large number of them having worn out engines, use of excessive lubricating oil and adulteration with diesel or kerosene in the petrol by the operators. These factors lead to very high HC levels.

Short term: *HC standards need to be prescribed*

Long term: A specific programme for upgradation of all the existing oil refineries and reformulation of fuel quality has to be started immediately and specific target dates have to be fixed with regard to supply of diesel with reduced sulphur content and unleaded petrol throughout the country through MOP & NG (with private sector participation in view). The

Ministry of Industries also need to give order to the vehicle manufacturers for producing cars fitted with catalytic converters.

Strategy 2: Stricter pollution checks

Under the amended Motor Vehicles Rules 1989, limits of idling carbon monoxide for petrol driven vehicles and smoke density for diesel driven have been prescribed and it came into force with effect from March, 1990. The limits are given in table 3 below

Table 3: Limits of vehicular emission

Vehicle type	limit
four wheeled petrol driven	CO - 3% by volume
2 & 3 wheeled petrol driven	CO - 4 5% by volume
diesel driven	smoke density - 65 hartridge

Pollution checking is carried out by (i) the Transport Department through their various static units and mobile teams and (ii) in the authorised petrol pumps and workshops A number of gas filling stations are authorised to carry out the checks on the vehicles and a sticker on a periodical basis is issued to the checked vehicle. Under the Motor Vehicles Act, necessary provisions have been made for possession of a PUC ("Pollution under Control Certificate") by all vehicles and also a fine of Rs.1000 in case of violation of the norms for the first time. Further, this offence has been made compoundable with fine of Rs 2000 next time onwards.

The measure of pollution checking which is practised only in the larger cities, like Delhi, needs to be extended to other cities. Further, measures like pollution checking of all new and old vehicles at the time of registration (as prescribed in Delhi Motor Vehicles Rules, 1993) should also be adopted in other large, medium and small size cities

Measure: Stricter pollution checking

Short term. More frequent pollution checking than the presently prescribed 6 months should be carried out for all vehicles including public buses in all cities. Private Entrepreneurs / municipalities / local bodies be involved in cities where system of monitoring does not exist.

Short term: The number of pollution control squads (mobile teams) and number of authorised petrol pumps should be increased in order to facilitate the process for all cities (In Delhi itself, for a vehicular population of 2.2 million, number of authorised fuelling stations (for carrying out pollution checking) are 121; considering about 7 minutes for checking one vehicle and checking every 3 months (as earlier) each station would have to check 200 vehicles per day), with the recently introduced timeframe of 6 months, the number of vehicles would be 100. However, it would make better environmental sense to increase the number of stations than extending the period of checks since irrespective of the number of km run by any vehicle, the "owners manual" of all vehicles ahead specify a "service" of the vehicle after every 3 months.

Short term Strict checking of adulteration in fuel at user end should be initiated immediately.

The responsibility of pollution checking in each city be handed over to the proposed municipal committee. The fines and fees taken for issuing certificates would be revenue generated to the corporation. The state government needs to issue order for transfer of responsibility from Transport Department to the corporation.

Measure: Awareness programmes

Short term· Data on ambient air quality of highly polluted cities collected by the CPCB and SPCB should be regularly featured on the tele-text service of Doordarshan and other media to enable the public to know about the air quality prevailing in various cities. Data of monitoring stations of CPCB and SPCB should be displayed on electronic signboards at the monitoring stations and major traffic intersections. Execution of this measure should be carried out by the corporation.

Industrial sector

The major issues regarding industrial air pollution in the urban centres are as under.

- Pollution generation from Small Scale Industries
- Non-conforming industries
- Industries not adopting the various pollution control mechanisms like
  - pollution control devices
  - tree plantation in and around industries
  - Environmental Audits
- Technological interventions
  - Recycling of waste
  - cogeneration
  - interfuel substitution
  - reducing high ash content in coal

The issues, strategies and recommended measures are discussed below:

Issue 1/ Pollution generation from SSIS

The SSIs are a large contributor to the environmental degradation and most of them are using old and obsolete technologies. It has been observed that most of the SSIs are reluctant to accept newer technology, now available all over the world, due to heavy investment and further being pessimistic about its results, although the newer technologies were developed and accepted not only to save the environment but also to save the expensive mineral resources resulting in great saving to the investors and paying by its own over a limited period. In order to make such technology attractive, acceptable and aware to the entrepreneurs, it is necessary that few model units at least are established with pollution-free technology, particularly in the areas of electroplating, food processing and spray paints units.

Nonetheless, it is not possible for the Pollution Control Boards alone to initiate the process of monitoring as well as educational programmes for environment awareness and public participation is essential to protect the environment. Without creating awareness amongst the industrialists and the workers together, the pollution prevention programmes cannot be successful.

The following strategies and measures are recommended for the SSIs.

Strategy: Identification and pollution control of SSIS

Short term The unregistered small scale industries located in various parts of city including residential areas needs to be identified by the proposed municipal committee, they can get it done either by departmental survey or by NGOs etc. They can be given orders to shift/close down if found polluting The committee is also responsible for providing space to the identified small scale polluting industries in a suitable area at nominal price along with basic infrastructures like roads, electricity and water connection etc.

Short/Long term Compulsory registration of all industries with respective government department, irrespective of size and type. Registration be made attractive by providing incentives like the above concession.

Short term: The SSIs be motivated and subsidies/loans provided for modernization with aim for minimisation pollution SIDCs to act as Implementation Agency to undertake pollution prevention and environmental improvement efforts. The following actions are required

- Change in the raw-material and conservation of input resources,
- Modify the production process, equipments, operational parameters or the technology itself;
- Improvement in production efficiency and procedures;
- Recovery, re-cycle and re-use the wastes within the plant

Medium/Long term: Consideration of environment and pollution abatement measures be incorporated as one of the conditions of allotment of land and lease deed.

Medium term: Continuous amendments in the rules in various Acts so as to bring in more and more industries under their purview and they are made according to the needs of the industry.

Issue 2/ Non-conforming industries

An effort towards the control of air pollution from a locational point of view has been the identification and shifting of non-conforming industries

As per the provision of master Plan of Delhi-2001 no new industrial units to be set up in Delhi and the existing hazardous and noxious industrial units to be closed down or shifted. DDA has already served notices to 10 heavy and large/hazardous and noxious units to close down or shifted from Delhi. The Delhi and the Bombay Master Plans have allocated land for shifting of the non-conforming industries. Enforcement of these provisions, however, has been quite unsuccessful. In effect, the non-conforming industries have retained their existing locations, with some modifications or limited action towards pollution abatement. *A major reason for this situation is that, neither the costs of staying in its present location nor the benefits of moving to a new location are high enough* to any so called non-conforming industry,

In fact, the provisions of the Urban Land Ceiling Act which prevent the lands vacated by industries to be put to other profitable uses as also the high rates of tax on the capital gains derived from such land transactions act as a disincentive for such shifting The only major instance of such a shift which has taken place in Delhi relates to the Delhi Cloth Mills, which has been closed down and the land is being used for now flatted factories and middle/upper income housing.

Strategy: Relocation of non conforming industries

The measures and corresponding actions are:

***Measure:** Delineate sites for relocating industries*

Medium term: The Regional Plans / Master Plans prepared by the Regional Development Authorities /Urban Improvement Trusts /Local Bodies of the cities should delineate sites and areas for sitting industries as well as new industries.

Measure: Shifting of polluting industries

Medium term: Non-conforming industries be shifted. Suitable strategies for the relocation / closing of toxic / hazardous industries in phased manner in the major cities or equipping them with air pollution control devices need to be deviced. State Government should furnish a list of such industries and immediate directive to the industries to be given for shifting out within stipulated timeframe A system of incentives for relocating can be considered and a heavy penalty against those who do not shift out within time limits

Measure: Revision of urban land ceiling act

Long term: The capital gains tax and urban land ceiling are major obstacles and disincentives to relocation of polluting industries and they may be revised

Issue 3/ Industries not adopting the pollution control mechanisms

The various means for controlling pollution are:

(1) Adoption of air pollution control devices

This is one of the important mechanisms for limiting the emissions within the prescribed CPCB standards. But, it is not adopted by most of the industries due to various reasons like the expensive technologies, reduction of the productivity / efficiency due to their application, unavailability of appropriate and economic technology, lack of awareness, no mechanism of penalty for and the most important reason being lack of enforcement Although some incentives such as a 100% tax depreciation for the installation of pollution control equipment have been approved, appropriate incentive/disincentive structures need to be defined that would ensure the operation of such equipment as well. Also, the penalties for violating prescribed environmental standards should be kept very high and institutional structures for monitoring and enforcing environmental standards need to be strengthened

Strategy: Enforcement and promotion of pollution control technologies

Measure: The following air pollution control methods to be adopted by industries to reduce/ control dust and so_2 emissions The other measures for promotion of these equipments are also mentioned below.

Short/Medium term. Dust control measures

Electrostatic precipitators (ESPs), Baghouse filters, Cyclones etc. can be effectively applied for controlling the emission of particulate matters from various sources.

Short/Medium term: SO2 control measures
Wet scrubbers should be installed at the stack to check the SO2 emissions. In addition, the minimum stack height be kept as per the prescribed limits of the pollution control boards so as to ensure dispersion of the pollutants over a wide area.

Short term: Subsidy (by the government), on the devices and incentives to all small, medium and large industries for their adoption, in order to encourage industries for using control technologies

Strict enforcement of environment law (adoption of control tech.) is required and heavy penalty against offenders would be applied. The guidelines on environmental standards and various pollution control methods needs to be clearly framed out by the MoEF which are to be enforced by pollution control boards in the industries. The pollution control boards of all states have their offices in capital cities and regional offices in major industrial areas. These regional offices will carry out mandatory inspection and confirm the application of adequate measures in all industries falling in their respective region. However, the municipal committee in each city would be mainly responsible for regular monitoring of the industries located within the city.

Short term· Awareness programmes by pollution control boards need to be carried out. Participation of NGOs be considered.

Medium term Adequate resource allocation by the government for funding R & D on various devices, their applicability and techno-economic feasibility in Indian industries.

(2) Plantation of trees inside and around industrial premises
Industries should plant trees and ensure vegetal cover in their premises, especially in large and medium scale industries and industrial towns. Policy of plantation of trees has been made compulsory by MOEF but it is not practiced strictly. The concept of greening exists in a few industrial areas (Talcher for example) and it should be made compulsory in all industries.

Green belt surrounding industries and large industrial premises is also required.

Strategy: Tree plantation around industries

Measures: The following short and medium term measures are recommended for ensuring green belt

Short term: *Listing of industry specific plantation*
The MOEF, ministry of industries and pollution control board together need to prepare a list of specific types of trees required to be planted for each category of industry. The list should be made available to all industries, development authorities and local bodies

Medium term: Plantation of trees within industrial premises
Tree plantation of the specific type be made mandatory for each industry. The proposed environment management cell within each industry would be responsible for the plantation and maintenances. Pollution control board and their regional offices would carry on necessary inspections and penalise the noncomplying industries.

Short/Medium term *Plantation and maintenance of trees around industries*
It will be the responsibility of the municipality of each city (having one horticulture person already in large cities) and they should allocate budget for this separately The involvement of pollution control boards in selecting type of species and trees would be considered. In small cities, the responsibility of plantation lies with local bodies and responsibility of monitoring and maintenance of greenary be given to NGOs.

(3) Environment audit
Submission of an audit report has been made compulsory for all industries which require authorisation under the Air, Water and Environment protection Acts, in each financial year However, the policy does not specify as to (i) who should be preparing the report, the industry itself or any authorised agency (government / NGOs) and (ii) under what capacity Hence, it is extremely urgent and important to specify details regarding the above issues

Strategy: Compulsory environmental audits
The following measures are required for fulfilling the enforcement regarding the report

Medium term. Strict enforcement of environmental audits of industries The pollution control board and the municipal committee of the cities should be responsible for carrying out the audits every year After thorough examination of the reports they should also specify the necessary measures to be adopted by each industry

Long term. Mandatory surprise inspection of the industries by state pollution control board and regular inspection by the municipality to confirm application of the control devices.

Issue 4/ Technological interventions

Strategy 1: Recycling of waste

One of the important areas of recycling and waste recovery is the utilisation of fly ash from thermal plants and other industries, phospho gypsum and red mud from aluminum factories, for construction purposes. A Building Materials Promotions and Technology Council has been established by the Government of India under inter-ministerial guidance to promote and disseminate technologies of waste utilisation for building materials and to assist in their manufacture. The fly ash can be used in brick manufacturing, cement factories and as a filling material during construction of roads. The government also provides depreciation allowance of 50%, concessional customs and excise duties, and rebate of 70% from water cess for industries using prevention/treatment equipment.

Measure: Promoting manufacture of products using solid wastes through incentives like land at minimal price, concession on electricity tariff etc to manufacturers. An incentive scheme for cement manufacturers for using fly ash be considered. A wider use would be encouraged by adopting policy measures like compulsory use of these products for government construction. The Building Material Promotion Technology Council (BMPTC) existing under the MoUD should be involved in the process.

Strategy 2: Use of cleaner fuel in industries

Recognising that coal would continue to be the dominant fuel used in the Indian industry, it is imperative that the adoption of cleaner coal technologies - such as the fluidised bed boilers or integrated gasification combined cycle (IGCC) plants - is encouraged actively both in industry and power generating plants. The washing of non-coking coal to be moved over distances longer than 1000 kms for thermal power plants of 500 MW and above capacities is being made mandatory by MOEF. Although the consumers of coal will have to pay a larger price for the washed coal, this may be offset to a very large extent through the reduced handling costs associated with the high ash in coal, ash disposal costs and improved efficiencies and plant utilisation factors. This would result in environmental benefits like reduction of CO2 emissions, lower quantities of ash to be handled and improved performance of ESPs, etc.

Measure: Washing of non-coking coal

Long term: The Ministry of coal has to expedite the process of sanctioning coal washeries to be set up by public / private sector. Simultaneously the washery rejects can be utilised to generate the electricity for local needs by adopting fluidised bed boiler technology.

Long term: Research on these technologies (IFCC etc.) to be adapted in Indian conditions

Strategy 3: Promotion of cogeneration

The concept of cogeneration implying the concurrent production of electricity alongwith the output/product and process heat in a single integrated utility system is significant due to the rising costs of energy and the environmental benefits associated. The advantage of cogeneration lies in the simultaneous generation of thermal and electrical energy The technology is already successful in countries like USA, Australia, Japan and South Korea Using cogeneration, industries like sugar, fertilizer, chemicals, petrochemicals, cement, etc. can generate their own captive power at a substantially reduced cost. This is made possible either by adopting topping cycles or bottoming cycles. In many cases, enough electricity can be generated by the factories to actually sell it to the state grid. It has been estimated that nearly 8,000 MW of cogeneration power potential exists in industrial sector alone.

Cogeneration schemes offer large environmental benefits, both at the global and local levels. From the global perspective, there is a net reduction in the emissions of GHGs, especially CO_2, because the power produced by cogeneration plants replaces the power generation from utilities. Similarly, the emission of other polluting gases like NO_x and SO_x would also be correspondingly lower The other environmental benefits like decreasing pollution loads from reduced transportation requirements for coal/oil, decreased mining needs etc. would also take place.

However, cogeneration is a recent technology and its popularity is yet to be established. The government can consider enforcing legislations necessitating the industries to cogenerate power. In certain countries like Taiwan and South Korea, all the new cement plants which come up are required by law to put up cogeneration facilities

The following strategies are recommended for promoting cogeneration in the Indian industry·

(i) information dissemination

(ii) technical and financial options including technology transfer

(iii) institutional and regulatory framework; and

(iv) incentives

Issue 4/ Technological interventions

Strategy 1: Recycling of waste

One of the important areas of recycling and waste recovery is the utilisation of fly ash from thermal plants and other industries, phospho gypsum and red mud from aluminum factories, for construction purposes. A Building Materials Promotions and Technology Council has been established by the Government of India under inter-ministerial guidance to promote and disseminate technologies of waste utilisation for building materials and to assist in their manufacture. The fly ash can be used in brick manufacturing, cement factories and as a filling material during construction of roads. The government also provides depreciation allowance of 50%, concessional customs and excise duties, and rebate of 70% from water cess for industries using prevention/treatment equipment.

Measure: Promoting manufacture of products using solid wastes through incentives like land at minimal price, concession on electricity tariff etc. to manufacturers. An incentive scheme for cement manufacturers for using fly ash be considered. A wider use would be encouraged by adopting policy measures like compulsory use of these products for government construction The Building Material Promotion Technology Council (BMPTC) existing under the MoUD should be involved in the process.

Strategy 2: Use of cleaner fuel in industries

Recognising that coal would continue to be the dominant fuel used in the Indian industry, it is imperative that the adoption of cleaner coal technologies - such as the fluidised bed boilers or integrated gasification combined cycle (IGCC) plants - is encouraged actively both in industry and power generating plants. The washing of non-coking coal to be moved over distances longer than 1000 kms for thermal power plants of 500 MW and above capacities is being made mandatory by MOEF. Although the consumers of coal will have to pay a larger price for the washed coal, this may be offset to a very large extent through the reduced handling costs associated with the high ash in coal, ash disposal costs and improved efficiencies and plant utilisation factors. This would result in environmental benefits like reduction of CO2 emissions, lower quantities of ash to be handled and improved performance of ESPs, etc.

Measure: Washing of non-coking coal

Long term: The Ministry of coal has to expedite the process of sanctioning coal washeries to be set up by public / private sector. Simultaneously the washery rejects can be utilised to generate the electricity for local needs by adopting fluidised bed boiler technology.

Long term: Research on these technologies (IFCC etc.) to be adapted in Indian conditions

Strategy 3: Promotion of cogeneration

The concept of cogeneration implying the concurrent production of electricity alongwith the output/product and process heat in a single integrated utility system is significant due to the rising costs of energy and the environmental benefits associated. The advantage of cogeneration lies in the simultaneous generation of thermal and electrical energy The technology is already successful in countries like USA, Australia, Japan and South Korea Using cogeneration, industries like sugar, fertilizer, chemicals, petrochemicals, cement, etc can generate their own captive power at a substantially reduced cost. This is made possible either by adopting topping cycles or bottoming cycles. In many cases, enough electricity can be generated by the factories to actually sell it to the state grid. It has been estimated that nearly 8,000 MW of cogeneration power potential exists in industrial sector alone

Cogeneration schemes offer large environmental benefits, both at the global and local levels. From the global perspective, there is a net reduction in the emissions of GHGs, especially CO_2, because the power produced by cogeneration plants replaces the power generation from utilities. Similarly, the emission of other polluting gases like NO_x and SO_x would also be correspondingly lower The other environmental benefits like decreasing pollution loads from reduced transportation requirements for coal/oil, decreased mining needs etc. would also take place.

However, cogeneration is a recent technology and its popularity is yet to be established The government can consider enforcing legislations necessitating the industries to cogenerate power In certain countries like Taiwan and South Korea, all the new cement plants which come up are required by law to put up cogeneration facilities

The following strategies are recommended for promoting cogeneration in the Indian industry·

(i) information dissemination
(ii) technical and financial options including technology transfer
(iii) institutional and regulatory framework; and
(iv) incentives

Measure: Information dissemination

Medium term: Establish industrial information centers on a regional/national basis as well as sectoral basis. These centers will communicate with both manufacturers / suppliers of energy efficient technologies (including cogeneration options) and individual industrial plants within the respective sector. They would store information on technical and organizational experiences in other countries.

Measure: Technical and financial options including technology transfer

Medium term: Promotion of R&D activities alongwith technical manpower development and upgrading of skills. Training programmes by technology suppliers, Government agencies and multilateral bodies has to take place. Investment promotion mechanisms like foreign investments, loans from international financial institutions at attractive rates need to be considered.

Measure: Formulation of institutional and regulatory framework

Short term: Develop regulatory reforms and institutional work especially for plants producing electricity in excess of their captive requirements. Till now, no policy by Central and State Governments exists regarding the sale of cogenerated power to the grid. A policy framework ensuring commitment by SEBs to purchase power from plants at mutually acceptable rates is very much essential.

Measure: Promotion through incentives

Short term: Cogeneration can be promoted by providing proper incentives. In the Indian cement industry, nearly 720 MW of power is generated from nonutility sources by the plants themselves of which 546 MW is based on captive diesel generating sets. This has happened mainly due to the erratic power supply from the SEBs. In order to curtail the dependence on the scarce petroleum resources, such plants can be provided certain fiscal incentives like low duties on imported cogeneration equipment, etc. to promote adoption of waste heat recovery systems for cogenerating power.

All the above mentioned measures for promotion of Cogeneration would require involvement and support of the MNES and Ministry of Industries.

Strategy 4: Meet increased fuel demand through alternate fuel; interfuel substitution

Interfuel substitution implies a shift to low carbon fuels, mainly natural gas and hydropower According to a recent estimate the electricity generation capacity would have to be increased from about 70,000 MW in 1991-92 to a little over 210,000 MW in 2011-12, an increase of 7,000 MW on an average every year. A major share of this increase is planned to be met through coal based power plants. Any shift towards the use of natural gas or hydro-power for electricity generation would lead to a reduced demand for coal and thereby a reduction in emission.

Thus for an overall system efficiency and to limit pollution from coal based industries and thermal power plants, share of natural gas and hydro power capacity needs to be increased Considerable quantity of natural gas is still being flared in various gas fields, especially in the North-Eastern region Effective utilisation of natural gas would directly result in reduced consumption of oil and coal Environmental benefit arising from increased usage of natural gas emanates from the fact that it has lower carbon content per unit of energy released (i.e. kg of C per KCal of heat released).

Increasing the share of hydropower also has a major influence on reducing the release of various polluting gases into the atmosphere. However, this option has to be studied in a more comprehensive and site-specific manner

Interfuel substitution also has another dimension in the form of shift towards utilisation of renewable sources of energy The technologies utilising wind, solar, biogas etc are more environmentally sound as compared to the conventional coal/oil options in terms of limiting the release of polluting gases

The following recommendations are suggested.

Measure: Increase share of hydro and natural gas in power generation

Medium term Replace small gestation power plants by natural gas based power generation to meet the peaking requirements

Medium term: The government has to give greater incentives and a larger share of its budgetary support for hydro-power capacity expansion.

However, for deciding on the shares of hydro, natural gas and coal in power generation would require detailed analysis of their availability, their economic feasibility and also demand in other sectors. Hence this should be decided by the concerned bodies like Ministry of Power, MP&NG, Ministry of Coal and others.

Domestic sector

The issues in the domestic sector air pollution and the recommended strategies and measures are discussed below.

Issue 1/ Increased use of biomass fuels

Strategy 1: Effective utilization of energy resources

The use of biomass fuels in poorly ventilated homes puts the inhabitants (especially the women and children) under considerable risk.

Measure 1: Introduction of piped gas using natural gas/coal gas and biogas

Use of biogas in piped gas has tremendous potential to reduce the high concentration of indoor air pollutants. The other secondary benefits include checking the pace of deforestation (Appendix IV). Furthermore, the individual size biogas plant will have a short payback period (a typical 2cum individual size biogas plant costs about Rs.8,000) as the urban poor will stop purchasing firewood and other biomass fuel. The use of biogas should be adapted to suit the needs and size of the urban centres. In the larger cities (class I,II,III) where it is difficult to keep and maintain livestock, the use of biogas could perhaps be linked with sanitation. The possibility of piped gas needs to be explored in the big cities. The use of animal manure based biogas is more suitable in smaller and medium size urban centres. The various possibilities in the small, medium and large cities are given in table 4.

Table 4: Possibilities of piped gas/biogas use

City Class	Possibilities of piped gas/biogas Use
Metropolitan cities	Piped Gas - In Bombay, natural gas will be available for domestic use (GAIL, British Gas-Joint Venture) by June this year In Calcutta, there is a proposal to supply coal gas for cooking In Delhi, GAIL plans to supply gas for home use by the year 2002
Large cities (Class I,II,III)	Sanitation linked biogas schemes Biogas plants linked to community/public toilets and/or central sewerage systems can be used to meet lighting (street/home), heating and possibly cooking needs in the poorer homes
Small cities (Class IV,V,VI)	Animal based biogas where possible

The slum dwellers in the larger cities have no agricultural land which can be tilled nor do they have any space to keep the cattle and livestock (no sheds, grazing land) Therefore there is little or no scope for animal based biogas generation in these urban areas Instead innovative schemes can be launched to adapt biogas production to suit urban slum conditions (large cities). For instance since many slums have poor sanitation facilities, the use of public toilets/community toilets would improve the sanitation and the human refuse could be used by biogas plants. Thus the dual objectives of reducing indoor air pollution and providing better sanitation facilities can be met. However peoples' reservations against using human refuse for domestic cooking have to be first overcome.

Civic authorities can also examine the possibility of biogas systems, linked to the sewerage system, to meet heating/street-lighting requirements in the larger cities A successful program has been adopted in some cities in China

Role of MC would be very critical to initiate and implement the schemes propound to encourage the use of animal based biogas (smaller towns/rural areas) and sanitation linked schemes (larger cities) following measures will have to be taken by the government and the NGOs.

(i) Technical Training for builders and users of these plants

Many of the family sized biogas plants set up are not operating This may be because of inadequate supply of manure, no maintenance or technical skills to carry out minor repairs, poor construction of plants etc It is to be ensured that the technicians (who construct the plants) and the beneficiaries (who can be taught how to repair/minor damages) are suitably trained *(ii) Demonstration/informational programs*

People's reservations against using animal/human wastes for cooking/lighting/heating purposes have to be dispelled to increase the penetration of biogas in urban/rural areas. The process should be explained and the benefits of the use of biogas should be emphasized. A few plants could be set up for demonstration purposes.

(iii) Subsidies/installment schemes

To encourage the installation of smaller capacity plants by the poorer segments of society and to increase the participation of the beneficiaries the government should continue/extend its incentive/subsidy schemes. Bank loans could also be given on concessional terms. At present the Central subsidies work out to about 20-35% of the estimated installation cost depending upon the size of the plant and the category of the beneficiary.

(iv) Marketing

The high grade manure (slurry) which is a by-product of the process has little use in the larger cities. To earn additional income, this manure may be sold in the surrounding rural areas. However marketing assistance may be required to initiate this scheme.

Similarly piped gas in large cities for domestic consumption is being introduced in a phased manner. About 90 households in Bombay will receive natural gas on a trial basis from June 1995. Mahanagar Gas Ltd, a joint venture between GAIL and British Gas plans to supply piped gas to over six lakh domestic customers by the end of 1997. The gas is expected to be cheaper than the 14.2 kg LPG cylinders However the installation charges, for the modification of stoves, regulators and special meters to monitor gas consumption, have to be borne by the consumers. These costs are expected to be prohibitively expensive (of the Rs 376.7 crore capital cost for the project, Rs.189 crores is expected to be covered by the customers). Though at present due to the initial expenses the middle/high income groups would be the users, there is potential in the medium/long term (as costs fall) to extend this service to the poorer households as well. There are pilot scale projects on supply of piped gas for home use in Calcutta (coal gas from nearby coalfields) and in Delhi (by recycling of solid waste) as well. The possibilities for extending similar schemes in other cities also need to be explored.

To check indoor air pollution arising from the burning of low grade fuels (biomass fuels) there is scope for shifting to better fuels due to its easier accessibility and availability and increasing affordability of people. The government's present policy of subsidizing LPG and particularly kerosene have made families shift to better fuels. A recent report on Delhi's slums by TERI - "Health risks and Cost Effective Interventions for Indoor Air Pollution" suggest that in Delhi there has been a shift away from firewood to other fuels (Kerosene, LPG). While a shift away from low grade to superior fuels is desirable, India, an oil importing country should try to promote the use of fuels like coal/coal gas in which it has an abundant supply.

Measure 2: Promote use of solar cookers

The use of solar cooker as a renewable energy device would also help in reducing the dependence on conventional energy sources

A recent questionnaire based survey of solar cooker (box-type) users in Delhi carried out by Centre for Energy Studies, IIT Delhi, revealed that a majority of the users belonged to the middle-to-high income groups with incomes varying from Rs.3000 to Rs 12000 per month. All the surveyed families owned a LPG gas stove in addition to their solar cooker. It is believed that the consumer in both rural and urban areas view solar cookers as a viable complement to but not a substitute for their current cooking systems. Some of the reasons for these are:

- These cookers can be primarily used for boiling purposes, therefore its use in most of North India and other roti-eating areas in the nation is somewhat limited It could howcver be used by the rice eaters. Recent improvements in designs, have made it possible to cook roti's on these cookers as well; but their efficacy is yet to be fully established
- On cloudy and rainy days the solar cooker cannot be used Moreover the efficiency of the cooker (the food is sometimes only partially cooked) is reduced in the winter months.
- For many of the urban poor (also the working women) cooking is usually done early in the morning and/or in the evening, this makes the use of a solar cooker very unpractical as it involves a change in lifestyles. Furthermore most of the users feel that cooking on solar cookers is more time consuming.

As the poorer sections of the population can hardly afford to make such an investment for a cooker which is a complement to and not a substitute for their chulahs, its scope in reducing indoor air pollution especially in the slums is limited. However, there is considerable potential of popularizing the solar cooker (environmentally friendly, energy efficient) among the middle and upper income groups. The Government should consider:

- encouraging R&D efforts for designing lighter, more compact and improved solar cookers which would reduce the uncertainty in cooking the meal.
- Reliable after sales service should be provided to prevent discontinuation of the solar cooker use due to minor repair & maintenance problems The materials used for the construction of these cookers should be monitored as the survey found that the use of sub standard materials, poor craftsmanship and lack of repair and maintenance services has dampened the enthusiasm of current and potential users of these cookers.
- Demonstration programs and publicity should be given to further popularize these cookers.

Strategy 2: The use of improved cooking stoves

Traditional methods of cooking in India involve the burning of wood or other biomass fuels in an open fire or a horse-shoe shaped mud stove (chulah). These cooking systems are very energy inefficient (about 10% thermal efficiency-MNES Annual Report 1992-93) and are highly polluting. Improvements in the chulah design would lead to savings in the amount of biomass fuels consumed (checking the pace of deforestation). Furthermore, the women and children can find additional employment and income by working as chulah builders. The use of more energy efficient and less polluting cooking stoves can be therefore extended on a large scale particularly in slum areas.

The MNES has set a target of installing 18 million improved (smokeless) chulahs in the VIIIth Five Year Plan period in rural areas. It seems well on its way of meeting (or even exceeding) its target as by March 1993, 14 5 million chulahs had already been installed. Though a good beginning has been made, there is still a long way to go. R&D for further improvements in chulah design (and costs) should be intensified. The design of chulahs should meet local needs and infact their suggestions should be incorporated in the design for these stoves to gain wider acceptability Similarly programme could be initiated in urban slum pockets. Voluntary agencies should assume a greater role in promoting improved cooking stoves in both urban and rural areas.

While there are many merits in adopting smokeless and other improved chulahs in place of the existing energy inefficient and polluting chulahs they have not be popularized adequately by the government and the voluntary agencies (NGOs). To increase the penetration of improved chulahs the following measures are required.

Measure 1: Technical/informational programs

The targets being set for states by MNES are being extended in some states, but in a bid to meet or exceed targets inadequate attention has been given to technical and informational programs. The users should be taught how to construct and make minor repairs to the chulahs Studies on the energy efficiency (and the resultant firewood saved) of the new stoves should be published and the pay back period of such chulahs may then be tabulated (though in areas where firewood is collected and not bought this may not be possible). Demonstration and other publicity programs should be continued to generate greater awareness

Measure 2: Greater local participation & adapting designs to meet local conditions

The chulahs have to be adapted to meet different local conditions. For instance a two-hole chulah is more suitable for the plains while a three-hole chulah functions better at higher altitudes. The size of the utensils should also be borne in mind while trying to construct such chulahs. Often the chulah hole is too large for the utensil causing problems for the household Local participation may be necessary for greater acceptability A few people can be trained to assemble/construct these stoves thereby providing additional income and employment to them Local suggestions could be incorporated in the designing of the new cookstoves

Measure 3: R&D for further improvements

The National Program on Improved Chulha (NPIC) started in 1983, has made significant contributions towards improving chulahs designs. Efforts must continue to develop chulahs which increase efficiency (reducing fuel consumption and cooking time), reduce pollutant emission and are cheaper (making them more affordable)

Measure 4: Greater publicity campaign

To promote increasing use of improved cookstoves, awareness programes must be launched through the help of media, campaign etc

Issue 2/ Excessive electricity consumption

Strategy: Demand side management (dsm) in the domestic sector

The contribution of the household sector to the deterioration of the air quality may be both direct and indirect. The harmful facets of indoor air pollution have already been examined in some detail, we now turn to the rising energy requirements (electricity). With demand outpacing supply the deficit of electricity over requirements is expected to grow from 8.3% in 1992-93 to 9.04% by 1996-97. The deficit during peak loads is even greater, by 1996-97, the shortage is estimated to be around 15263 MW which is 20.72% of the peak demand.

The bulk of our electricity requirements (73%,March 1993) are met by thermal power plants (which are very polluting) With increasing consumerism especially in urban areas and the increased purchase and use of domestic appliances; an additional burden has been placed on our power requirements. The use of electricity for domestic purposes has risen from 14.23% in 1990-91 to 16.51% in 1994-95 (see table 3) and is expected to grow further to over 210,000 MW by 2011-12. What compounds the problem is the wasteful and indiscriminate use of electricity by some segments of the urban population (leaving appliances, lights, fans etc. switched on when not in use). Information/awareness campaigns, a revised tariff structure and peak load management are required to arrest this disturbing trend.

Table 5: Consumer category-wise sales of electricity (%)

CATEGORY	1990-91	1994-95
Domestic	14.23	16.51
Commercial	4.14	4.75
Agriculture	27.18	27.55
Industry	35.82	37.80
Others	18.63	13.39

Source Annual Report on the working of SEBs & Electricity Depts (Planning Commission, GOI-Feb'94)

There is considerable scope for demand side management (dsm) in urban households, for instance, the use of FTLs and CFLs in place of GLSs is one such possible measure. The use of pressure cookers for cooking (it is more energy efficient) is another example of dsm at the household level. However for any policy to be effective, public awareness programs are essential. As the benefits of electricity conservation accrue directly to the consumer (who has to pay smaller electricity bills) information programs (capsules on TV, radio, written media) would serve as reminders to the general public and could promote the adoption of such measures.

III. Conclusion

With growing urbanisation and deteriorating urban environment an air quality management plan should be developed and implemented mainly in the large size cities to start with for attaining sustainable urban development.

The air quality in various cities are monitored by various agencies who have their monitoring stations located in one or more locations in the cities Though this data is available to get an aggregate environment profile for some selected cities (mainly large and medium), *very little inferences can be drawn* regarding critical zones within the city (where the concentrations are very high) and the sources of emission It is extremely important to take note of the *sectoral* contributions of emissions of different pollutants in various pockets of a city for carrying out any environmental planning exercise. This indicates that there is an utmost need to devise a common methodological framework which can be adopted to estimate the emission of different pollutants from the various sectors in different pockets Such a common framework is required due to lack of knowledge on the nature and magnitude of air quality in urban areas.

For immediate actions in order to reduce the urban air pollution, a range of strategies and measures are recommended in the *three air polluting sectors* of domestic, industry and transport sectors. It is also realised that without an institutional and legal framework within the cities, it would not be possible to implement the required measures in the different ones Hence the municipal committee is proposed at the city level for each city so as to ensure proper enforcement of measures and environmental monitoring

Lastly, for enabling an accurate planning and its implementation there is an urgent need to prepare base maps, landuse maps and pollution maps for all the urban centres Without spatial maps and plotting all environmental depletion and degradation simultaneously, sustainable development can be never achieved. The powerful tools like GIS can be considered in this regard

IV. A case of Delhi

In the meeting held at the MoUD on July 6, 1995 to discuss the draft strategy papers prepared by the various institutions it was suggested that TERI could include a case study of Delhi in their paper on urban air pollution keeping in view the recommended measures

This paper on Delhi briefly describes the environmental degradation (air quality) that has occurred over the last few decades. The study gives an overview of the sectoral growth and emission inventory of the transport, industry and domestic sectors. The study concludes with a sectoral list of measures that need to be undertaken in the short, medium and long term.

However, no measure is complete until and unless a detailed techno-economic feasibility is undertaken. To facilitate this process, the MC would have to take the lead role in implementing the required measures. A range of possible options for implementation in Delhi has been listed; the implementation process would have to be worked out by the MC.

Demography

Delhi's population profile over the twentieth century is shown in table 1.

Table 1: Population growth in Delhi

Year	1901	1911	1921	1931	1941	1951	1961	1971	9181	1991
Population	405819	413851	488452	6362246	917939	1744072	2658612	4065698	6220406	9420644

Source Delhi Statistical Hand Book, 1994, Directorate of Economics and Statistics, New Delhi

Table 1 shows that between 1901 and 1971, the population increased almost ten times. Simultaneously, the urban limits of Delhi also changed/expanded considerably. However, in recent times, the population growth has been enormous, a decadal rate of growth of increase of 53 percent over the period 1971-81 and 51 45 percent over 1981-91. Assuming a similar rate of growth of population over 1991-2001, the population by the year 2001, is expected to reach 14 3 million approximately This 14 3 millions of people would have to be accommodated within the existing city thereby increasing the population density (persons per square kilometer) considerably.

Transport

Presently, the total number of vehicles in Delhi is 2.2 million and it has been estimated that about 1,50,000 vehicles are added every year. Vehicular population in Delhi has increased steeply in the recent past, as is evident from table 2.

Table 2: Growth of registered vehicles in Delhi

Name of vehicle	1971	1981	1991	1994
Cars/Jeeps	56450	119495	398479	522264
Motor cycles and Scooters	93263	345109	1220640	1492201
Auto rickshaws	10221	20379	63005	72102
Taxis	3842	6385	10157	11846
Buses	3038	8044	18858	24211
Goods vehicles	13620	36599	101828	116379

Source Directorate of Transport, Delhi Administration

From the above statistics, it is seen that currently, about two-thirds of the registered vehicles are two-wheelers. Whereas cars and jeeps account for about 20 percent of the total vehicular population, auto-rickshaws constitute only 3 percent. Buses constitute 1 percent of the total registered vehicles and goods carrying vehicles account for 5 percent Needless to say that due to insufficient public transport services, the number of private vehicles is increasing rapidly

With the fast growing population, the transport needs have also been rising, resulting in an increased demand for public transportation facilities, and personal vehicles Presently, there are about 2 2 million vehicles plying on Delhi roads of which about 87% are personal vehicles Delhi has the longest road length, of 1284 km. per 100 sq km of area, in India The road network in the city is 22,487 km long Delhi also has a ring railway but, so far, it is not a major commuter mode

Substantial amount of the travel demand is met by the Delhi Transport Corporation (DTC), which alone carries about 55 lakh passengers daily. To provide a better public transport service, a large number of private buses were initiated in 1993 in a phased manner This includes the Redline and Whiteline bus service, in addition to the DTC buses Table 3 gives the details of public transport facilities in Delhi, for the year, 1993

Table 3: Public transport facilities in Delhi (1993)*

S No	Public transport	Numbers
1	DTC (1000 obsolete buses to be phased out from a total of 4,200)	3,200
2	Redline service (1,500 private buses under STA and DTC operation to merge with 3,000 Redline buses)	4,500
3	Whiteline Express	200
4	A C Blueline Express	Not specified
5	Motorcycle Taxi Service	500
6	Autorickshaw (existing)	68,000
7	Taxis (existing)	10,600

Source Hindustan Times, Jan 25, 1993
* Approximate numbers

To meet the complex and ever growing transportation requirements of the Capital, an integrated Mass Rapid Transit System (MRTS) has been suggested. According to a study conducted by the Rail India Technical and Economic Service (RITES), the proposed multimodal MRTS scheme (144 km. long) comprises of components of the existing rail corridors, a metro corridor and a corridor for a high capacity system.

Industries

Delhi has about 89,000 industries at present and it has shown a rapid expansion in the industrial sector, particularly in the last two decades. It is estimated that over 2500 new units are now coming up in the city every year. Table 4 gives the details of industrial growth in Delhi.

Table 4: Growth of Industries in Delhi.

Year	No of Industries
1951	8,000
1961	17,000
1965	23,000
1978	40,000
1981	46,000
1985	65,000
1990	81,000
1993	89,000

Source Central Pollution Control Board

In the organised industrial sector of Delhi, there are 173 large & medium units and 14248 SSI units (Source: Directorate of Industries, Delhi) all of which are located in the urban areas of Delhi Majority of the industries belong to the type of basic metals and metal product units, electric machinery units, paper pulp & printing units. About 5 per cent of these industries are located in rural areas and the rest 95 per cent are located in urban areas of Delhi There are 5 large and medium scale industries falling under the 17 categories of highly polluting industries.

Estimates show that, at present, there are about 75,000 industrial units in the unorganised sector Most of these units are in small sector. The types of industries include wire drawing, rubber/plastic goods, chemicals, electroplating, casting, printing, dying & processing, readymade garments, food products, soap & detergents, electrical & electronic goods, PVC goods, auto service stations, foundry, steel rolling, etc. Another important aspect is that, out of 89,000 existing units, only about 34,000 are having municipal license which is essential for registration as SSI unit and getting various facilities from official agencies

By 2001, the number of industrial units is likely increase to about 93,000 Also, trends show that non-conforming industrial units (according to existing industrial situations) are increasing very rapidly. A large number of the existing industries, about 70%, are in other than the planned industrial locations i.e , areas of residential & commercial land use and referred as non-confirming areas A significant number of them is highly hazardous and noxious like plastic products, steel polishing, metal finishing, etc which has penetrated deep into residential areas In the decade 1981-91, about 43,000 more industrial units have sprung up but no industrial estate has been developed in Delhi, except the DSIDC's Narela complex from 1800 units

At present there are 22 industrial areas, which are developed in a planned manner by various agencies over time But, there also about 35 non-conforming industrial areas as per Delhi Pollution Control Committee

Emissions inventory

The emission from the transport, industry and domestic sectors are given below

Transport sector

In Delhi, the total number of registered vehicles is about 22 lakhs which is more than the sum total of vehicles registered in 3 other metropolitan cities viz , Calcutta, Bombay and Madras

Estimates show that while petrol driven vehicles constitute 93 percent of the total vehicles, they contribute about 81 percent of the total pollutants emitted. Estimated vehicular emissions for CO are 3,60,000 t/yr, for HCs, 1,60,000 t/yr, for NOx, 23,000 t/yr, for Pb, 280 t/yr and for SPM 5,400 t/yr. Vehicular emissions account for approximately two thirds of the total air pollution in Delhi. This is due to the fact that the composition of petrol and diesel exhaust is characterized by a large amount of CO, HCs, oxides of nitrogen, SPM and SO_2. In the absence of any control of emissions from automobile sources, exhaust gases contribute significantly to urban air pollution.

Industrial sector

Amongst the various types of industries in Delhi, the most polluting ones are stone crushers, hot mix plants, potteries, etc. Besides the above important industrial air pollution sources, about 1,500 coal-fired boilers, foundries, forging units, etc. also contribute significantly to air pollution in Delhi. So far, 10 large, 18 medium and 31 small scale industries have provided air pollution control equipments.

An estimated 2,000 MT of pollutants are emitted every day in Delhi of which 29% is accounted for by the industrial emissions. Roughly there are about 1750 extremely polluting industries out of which 260 are identified as hazardous and noxious units (according to Department of Industries, Delhi Administration). The main sources of industrial pollution include thermal power plants, hot-mix plants, potteries, rolling mills, induction furnaces and stone crushers. More than 100 stone crushers within Delhi and about 50 stone crushers in the neighboring States create 15 to 40 times higher SPM concentrations than the limits prescribed by the Central Pollution Control Board (Supreme Court has ordered their closure). About 35 hot-mix plants, 20 pottery units, 33 induction furnaces, 1500 coal-fired boilers, foundries and forging units and 30 rolling mills contribute significantly to the pollution in Delhi.

Thermal Power Plants: Delhi has three major Thermal Power Stations (TPSs) to cater to its power requirements. The Indraprastha and Rajghat Power Stations have a capacity of 284 MW and 135 MW respectively. The Badarpur Power Station has a capacity of 720 MW. These three TSPs are equipped with ESPs to control dust emissions from their stacks. Sriram Food and Fertilisers Industry (S.R.F.F.I.) also has a captive power plant of 32 MW, equipped with multiclones. The details of emissions from these power plants are summarised in table 5 below:

Table 5: Emissions from TPSs in Delhi

Thermal Power Station	SO2	NO2	SPM
BTPS	59 29	34 89	36 39
ITPS	17 36	8 04	6 78
RTPS	14 18	7 65	7 76
SRFFI	19 83	12 89	1 45

Thus, pollution emissions from power stations account for a major share of total emissions. Further, unlike other industries, these power stations are located in the middle of the city, thus affecting the city population. Figure 5.17 shows the effected areas of the three power plants in Delhi.

Domestic sector

Pollutants from slow combustion of miscellaneous combustible materials by domestic and commercial sources account for 8 percent of the total pollution LPG, kerosene, coal, cow dung, wood straw, rice husk, and refuse are used for heating and cooking purposes in residential (domestic) areas. Although the high income population uses LPG, people in the lower income groups are still dependent on conventional fuel types for cooking such as kerosene oil, coal, wood etc. Sulphur dioxide is the major pollutant emitted, contributing the second largest amount to the total share of SO_2

It has been estimated that the total pollution load from the domestic burning of coal is about 108 MT/day Since these emissions take place at low heights, the problems due to domestic burning need proper attention in order to avoid any undesirable health effects

Delhi is termed as the 4th most polluted city in the world Particulate matter is the main pollutant besides sulphur dioxide and nitrogen oxides Industries, vehicular traffic and domestic burning are the major contributors to pollution in Delhi. Table 6 gives the present and projected percentage share of different sectors to air pollution in Delhi

Table 6: Sectoral share of air pollution in Delhi (percent)

Sector	1970-71	1980-81	1990-91	2000-01
Industry	56	40	29	20
Vehicular	23	42	63	72
Domestic	21	18	8	8

Source CPCB, New Delhi

From table 6, it can be observed that the share of vehicular pollution is increasing mainly on account of the fast growing vehicular population. Perhaps, it is only in case of the transport sector that vehicular growth will have a direct impact on pollution emissions, since it will directly result in the increased consumption of fuel However CO, HC, NOx and Pb are the main pollutants from vehicular traffic while particulate matter and sulphur dioxide are the main pollutants from industries and domestic burning A recent study conducted by CPCB for estimating source categories indicate the following. The major sources of SO_2 are industrial (82 percent). Two thirds of NOx emissions are contributed by traffic and one-thirds by point sources. Point sources contribute about 45 percent and the small scale industry contributes about 38 percent of the total SPM emissions The quantity of emissions contributed from each sector, therefore, depends to a large extent on the emission inventory. Sectorwise details are discussed below. The existing ambient air quality over the whole city is poor with certain areas experiencing *very high* levels of pollution. The table 7 below gives pollution levels at traffic intersections of Delhi.

Table 7: Pollution levels at traffic intersections in Delhi

S No	Traffic junction	CO $\mu g/m^3$	NO_x $\mu g/m^3$	HC PPM	Pb $\mu g/m^3$	Noise Leq(dB)
1	Dhaula Kuan	2333	100	8.5	14.5	81
2	Ashram Chowk	4278	118	7.2	8.9	87
3	Connaught Place	4583	138	7.4	6.8	-
4	Red Fort - Daryaganj Crossing	2981	155	10.2	5.5	-
5	Old Delhi Railway Station	6222	176	10.6	18.9	84
6	Chandni Chowk	2041	90	90.0	6.0	87
7	Shakarpur Crossing	2333	110	86.0	6.2	87

Source: CPCB, New Delhi

From the results, it is evident that all the intersections are severely polluted Major polluted corridors, with fast increasing traffic volumes, are of importance from the view of vehicular pollution. Aurobindo Marg, Patel Road, Netaji Subhash Marg and Panch-kuian Road are heavily congested roads. Passengers are worst affected on such highly congested roads The situation gets further aggravated if there is a presence of tall buildings on the roads, blocking the escape of pollutants Some such areas/junctions are Chandni Chowk, Darya Ganj, Mori Gate, Ajmeri Gate, Karol Bagh, Patel Nagar, Kirti Nagar, Kingsway Camp, Tilak Bridge, South Extension, Moolchand Crossing, Greater Kailash, and Nehru Place Most of the traffic intersections located on ring road are problem areas owing to heavy traffic

Strategies/measures for reducing air pollution in Delhi

The various strategies in the transport, industry and domestic sectors for implementation in order to improve the air quality situation of Delhi are listed below Two of the strategies are dealt in details, one in the transport sector and the other in the domestic

Transport sector - Short term measures:

- Facilitating the shift from personal to mass transport

One may assume that policy objectives with respect to the transport sector include providing a flexible and affordable mass transport service system with decreased levels of pollution, road overcrowding, fuel consumption, and also ensuring adequate safety levels The key constraint to realizing such a policy objective is the inability of the fiscal system to increase public investment and subsidy levels in the urban transportation

The principal option as already identified is to motivate shifts from personal (2, 3 wheelers and 4 wheelers) commuting to mass transport by allowing a flexible system of mass transport to come into existence, within the short term of 1-2 years Also, the mass transport system must ensure complementarity with the future MRTS/Ring railway in that they should furnish feeder services for the latter.

The key is to devise a policy/institutional framework to ensure competitive supply of transportation services by private operators, with a regulatory role only in respect of identified market failures, and a supporting role for a public, subsidized bus system

Competitive conditions through an effective market system will also in turn ensure long run marginal cost pricing of such services, ensuring the affordability of transport services The potential market failures include safety, pollution, fuel efficiency, skills/antecedents of drivers & support staff Further, in order to ensure flexibility, there must be no regulation of routes (except normal traffic restrictions), entry/exit of operators into the business, timings, comfort levels, fares. Additionally, there is a need to provide access to bus stops to all operators; and the number of bus stops need to be significantly increased in order to enhance flexibility and convenience of the transport service.

Specifically, the scheme may allow anyone to operate transport services in Delhi, subject to two kinds of licenses which should be displayed at all times in a highly visible manner:

(a) Vehicle licenses: based on vehicle safety, fuel consumption per pkm, and pollution emissions per pkm only.

(b) Operators license: based on skills of drivers and verification of antecedents for all.

Each of the licenses may be renewed every six months on continued satisfaction of their respective attributes. Additionally, the license fee for the buses may cover the costs of construction and maintenance of bus stops, and perhaps also generate significant revenues which may help raise investment funds for the MRTS. Operators' licenses need not be linked to specific vehicles, in order to help the emergence of a competitive labour market for drivers and other operating personnel.

The public subsidized bus system (DTC) may then focus on routes which are thinly served by private operators (due to relatively low density of transport demand), and on other routes frequented by poorer consumers (e.g. resettlement colonies).

De-regulation of routes, fares, and comfort levels would enable the private transport companies to respond quickly to change in transport demand, and to focus services on the precise nature of the demand (timing, terminal points, comfort levels). Compatibility with the MRTS/Ring railway is ensured by the fact of flexibility· the pattern of demand for feeder services required would be revealed in the market, and operators would have the freedom to respond to their demand.

Flexibility of the mass transport system would reduce the use of personal vehicles for commuting. The additional benefits that may be expected include significantly reduced air pollution, road crowding, fuel consumption, and road safety.

The other short term measures are:

- All encroachments should be removed with immediate effect in the roads.
- Lane driving system may be enforced on major and important roads.

- Movement of trucks be allowed only between 10 p.m. and 6 a m Over loading of trucks and other goods vehicles may be checked effectively.
- Point-to-point shuttle service by IPT between residential areas and the main roads/bus routes/bus terminals should be introduced
- Provision of parking lots may be made near or inside the bus terminals so that people can park their personal vehicles and take the bus. The revenue generated from parking fees can be utilized for increasing fleet of buses or reserved for construction of MRTS (corpus fund)
- Alternate routes provided for busy and congested traffic junctions and corridors exceeding their capacity as per the IRC standards
- To discourage use of Government and private cars by Government Officers, buses starting from Government colonies to Government offices may be introduced. If necessary, operation of such buses may be subsidized at the initial stages as an "incentive"/ "inducement" mechanism with the stipulation that employees using such facilities may be required to pay "reasonable" monthly charges.
- Similar kind of stipulations may be made for large industrial establishments The provision of low-pollution-high-quality public transport like bov buses can be considered in the long run
- No free parking be allowed in congested areas and market places
- Strict pollution checking should be carried out. The number of pollution control squads should be increased and testing procedures followed at all petrol pumps, garages and mobile squads be uniform and standardised. Personnel violating the provisions by issuing false PUC Certificates, would face cancellation of their licenses
- All vehicles, public/private should be subjected to pollution control test and action be initiated against those found polluting

Medium term measures

- Grade separation or additional lanes by road widening for heavily polluting intersections and high-density corridors be provided At places where enough land is not available for widening nor alternate routes are possible, acquisition of land is required for constructing additional lanes.
- Alternative environment friendly modes of transport such as CNG, battery powered electric vehicles need to be promoted to the maximum extent.

Long term measures

- The road layout and traffic management need extensive modernisation because the inadequate road network is unable to meet the increasing transportation load in Delhi. Lack of adequate control on proper land use and development has added to the traffic congestion and increased pollution. While planning the future extension pockets of Delhi, adequate area would have to be kept reserved under transportation use.
- The Mass Rapid Transport System should be introduced at the earliest. Rail-based mass transport system with feeder bus services and "unified" (rail-cum-bus) ticketing system must be promoted. This is a long-gestation projects and should be started now.
- The ring railway should be strengthened. The land-use along the ring railway and proposed MRTS alignment may be studied in detail so that the location of traffic-generating activities such as offices, business centres and educational (higher) institutions are along their routes. Delhi's Master Plan may be modified to locate District Centres along/near rail-lines if required.

Industrial Sector

Short term measures

- • Identification of the numerous unregistered small scale industries located in various parts of the city
  • Steps taken to enforce compliance with pollution standards for the polluting units.
- Dust control measures such as cyclones, etc. especially in small scale industries to be enforced.
- Green belts to be promoted around industrial estates.
- Environmental audit to be enforced with immediate effect.

Medium/long term measures

- Delineate adequate sites and shift nonconforming industries (small as well as large) alongwith enforcement of adequate pollution control devices.
- Industries to adopt recycling and waste recovery technologies. Incentives to be looked into in order to promote recycle and re-use.
- Use of cleaner fuel. The coal based power plants to consider using beneficiated coal.

- Energy conservation techniques such as co-generation and waste heat utilisation techniques to be actively promoted.

Domestic Sector

- Demand side management through optimum electricity consumption by replacement of conventional bulbs (incandescent and fluorescent) with compact fluorescent lamps

The option of retrofits of home/office lighting systems is the most significant feasible electricity saving measure in the short term period of 1-3 years

Even though the use of CFLs involves much lower electricity usage than conventional systems, with lifetime costs being only 50% of incandescents, the higher upfront costs (table 8) act as a deterrent to their ready acceptability with consumers It is therefore required that consumers be approached individually and their particular lighting needs assessed, in order to formulate individual plans, including financing, for effecting such change

Table 8: Electricity usage and costs of different bulbs/tubes

Type of lighting system	Capacity (watts)	Approx. cost of lamp and fixture (Rs)
CFL	7	700
Fluorescent tube	34	100
Incandescent bulb	60	20

It is thus necessary to devise an effective delivery system for CFLs (and other advanced lighting systems) to replace conventional forms of lighting For this it would be required to involve relevant State Government agencies, and private agencies operating competitively. Private agencies may be able to evaluate lighting retrofit requirements of numerous small consumers more efficiently than utilities However, the computerized billing system of utilities may reduce costs of collection of payments for the retrofit (capital and services), which would make such services financially viable. The flowchart (Fig 9 1) specifies the involvement of various organizations and their linkages which may be necessary in order that the system functions effectively.

The role of the Delhi Administration would be that of contributing capital outlay for the retrofit plan implementation. This money would be furnished to a revolving fund operated by a designated financial institution. The private retrofit service companies would get loans from the DFC revolving fund and provide retrofit services and loan purchase/lease of equipment. Consumers would pay for electricity, retrofit services, loan/lease and collection charges etc. which would be billed by the DESU/NDMC billing system, which would retain their own predetermined collection charges and electricity charges and pass on the rest to the designated financial institution. The revolving fund in turn would retain loan repayments due from the retrofit companies, and pass on the recovered payments for retrofit services to the companies. In order to ensure a competitive supply market for retrofit services, there should be no entry restrictions into the business except for technical qualifications.

- Reduction in biomass fuels by using alternative cleaner fuels and design of better ventilated homes especially in the slum areas. This would improve indoor air pollution.

References

---

1. ACMA. 1990. Automotive industry of India - facts and figures 1989-90. New Delhi: Automotive Component Manufacturers Association of India.
2. Bowonder, B. 1985. "Deforestation and fuel use in urban centres". Administrative Staff College of India, Hyderabad.
3. GOI. 1990a. Ambient air quality status of some cities/towns in India. Delhi: Central Pollution Control Board, Government of India. National Ambient Air Quality Monitoring Series - NAAQMS/2/1991-92.
4. Indian petroleum and natural gas statistics, 1993-94. Economics and Statistics Division, Ministry of Petroleum and Chemicals, Department of Petroleum and Natural Gas. Government of India.
5. OECD. 1991. Energy and the environment series - "Energy efficiency and the environment". International Energy Agency, Paris.
6. RITES. 1989. Mass rapid transport system for Delhi - Report on phase 1A. New Delhi: Rail India Technical and Economic Service Limited.
7. Saigal, O., Kumar, P., Gupta, R.K., Mudgal R. (1994). "Problems and prospects of industrial development in a metropolitan city".
8. Shukla, P.R. (1993). "Energy conservation and emission control policies in India for industrial and transport sectors", Indian Institute of Management, Ahmedabad.
9. State of art report on vehicle emissions. Indian Institute of Petrolem, Dehradun. 1985.
10. TERI. 1992. TERI Energy data directory and yearbook - 1990/91 (TEDDY 1990/1991). New Delhi: Tata Energy Research Institute.
11. TERI. 1991. "Energy efficiency of domestic appliance". Tata Energy Research Institute, New Delhi.
12. TERI. 1992. Impact of road transportation systems on energy and environment - an analysis of metropolitan cities of India. Tata Energy Research Institute, New Delhi.
13. TRF. 1993. Managing urban environment in India, Towards an agenda for action. Volumes 1,2 & 3.
14. Vimal, O.P. and Tyagi, P.D. 1984. "Energy from Biomass", Agricole Publishing Academy, New Delhi.